Adventures in Teaching: A Professor Goes to High School to Learn about Teaching Math

Darryl Yong

During the 2009–2010 academic year I did something unusual for a university mathematician on sabbatical: I taught high school mathematics in a large urban school district. This might not be so strange except that my school does not have a teacher preparation program and only graduates a few students per year who intend to be teachers. Why did I do this? I, like many of you, am deeply concerned about mathematics education and I wanted to see what a typical high school in my city is like. Because I regularly work with high school mathematics teachers, I wanted to experience the life of a high school teacher for myself. I had neither a research project nor an agenda for changing schools or teachers.

I kept a blog during my adventure, but it took some months after that experience before I could begin to process all that had happened. Four lessons emerged from my experience that I hope will give college and university educators a clearer view of what teaching high school mathematics is like.

Before we get to those four lessons, some background information might help. First, you should know that my story is not going to turn out like *Stand and Deliver*, *Dangerous Minds*, or any other inspirational Hollywood movie about a teacher who helped students achieve great things through painful sacrifice and struggle. The Hollywood idealization of a teacher as a martyr who sacrifices her personal life for the sake of her students propagates unrealistic and unhealthy expectations. Teaching is hard, but it shouldn't have to be that hard. This is also not the story of a professor coming down from his ivory tower and becoming outraged by the horrors of how children are taught in schools. I find these narratives unproductive. This article conveys one person's perceptions of the struggles that novice teachers face in one school and discusses what the general public rarely hears about public education.

I applied for teaching positions just like other teachers in my district, though I did not take all of the necessary steps to become credentialed. Visiting Faculty Permits, which were authorized between 2007 and 2013 through California Senate Bill 859 by Senator Jack Scott, gave me a convenient way to teach in the California public school system without a credential.

I was hired at a school that serves about 1,100 students. It is one of three high schools in a working-class neighborhood. Roughly 40 percent of the students at this high school are English language learners, 80 percent qualify for free or reduced meals, 85 percent identify as Hispanic or Latino. In 2009 only 3 percent of students at this school were deemed proficient on the Algebra 1 California Standards Test (CST). That year, I taught Algebra 1, Algebra 2, Geometry, and a math intervention class (an additional period of mathematics for students who are struggling in mathematics). Even though I taught four different classes, I did not teach a full load (six classes at this school). One of my Algebra 1 classes was an inclusion class—half of those students had learning disabilities or some other reason to warrant having an Individualized Education Program (IEP). In that class, all students, with IEPs or without, learned math together.

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In many respects I got what I wanted that year: an authentic experience of teaching in a high-need urban school. I didn't want to teach calculus or teach only "gifted" students. I didn't want to receive any concessions because of my qualifications. My experience was closer to that of a new high school teacher with no prior experience than that of a seasoned educator moving from one institution to another. I had to cut my teeth on many things like a rookie teacher. For example, I had to learn how to avoid taking things that students said or did to me personally. I learned that my students' behaviors in class were often a result of grave personal issues (violence, gangs, fear of deportation, etc.). I made many mistakes that year, but I was also spared many more mistakes because of trusted friends who are or were high school math teachers.

Lesson 1: Schools Are Complex Systems Involving People, Culture, and Policies

The news is full of stories about how our school systems are failing along with accompanying claimed explanations. There is a lot of blame that goes around, even at schools. I have heard some university mathematicians blame high school teachers for the poor preparation of their students. At this high school, I heard teachers blaming elementary school teachers for the poor preparation of their students.

During my short high school teaching experience, I learned that most explanations for why our schools are failing are simplistic and inadequate. For example, consider this frequently cited reason for our underperforming schools: bad teachers. We need to "hold teachers accountable" and "get rid of the bad teachers". I have yet to meet a teacher who willingly wants to be an ineffective instructor—every teacher I know has a desire to do a good job. Of course, I met math teachers at my school who didn't know their subject area as well as they should have. Nevertheless, the idea that we can simply replace "bad teachers" with enthusiastic new ones ignores the reality that years of hard work and experience are required to become an effective teacher. In addition, our schools and districts are not doing enough to help teachers grow in their content knowledge and teaching practice. (See Blog Entry 2 in Lesson 3 section.)

Some place blame on bad school administrators. In my opinion, our high school was poorly run, but our administrators didn't always have the resources to do their job well. Our administration mostly reacted to events and crises instead of implementing sensible practices. There was very little feedback given to us teachers about our teaching. In fact, over the entire year I had an administrator in my classroom observing me for a total of about ninety seconds. I received no meaningful feedback on my teaching. But it's difficult to blame him when you consider how understaffed the school was. Because the school lacked a counselor at the beginning of that school year, the assistant principal had to take on those responsibilities while supervising students during breaks, dealing with disciplinary issues, communicating with parents, and putting out fires.

Some people have asked me whether it was difficult to teach in a school with lots of poor families who didn't care about education. Not only is that stereotype inaccurate, it represents another line of reasoning that is simplistic. During that year I encountered some families who didn't seem to care about their kids' education and many that did. Sometimes when I called a student's home I would get a parent who was involved and would intervene, sometimes not. I encountered one young woman who returned to high school as a senior after having taken some time off to care for her baby. Unfortunately, right at the end of the school year, this woman's mother stopped offering to take care of her baby and she had to quit school. Does that mean her family didn't care about education? I don't think we can tell. I think the best we can say is that each student is a person whose attitudes and capacity for learning is greatly shaped by past and present circumstances.

Simplistic diagnoses are dangerous because they encourage quick fixes. Instead of long-term plans for systemic change, school reform becomes a series of short-lived fads that cause teachers to become jaded by unfulfilled promises of improvement. At my high school, la mode du jour was project-based learning (PBL). All teachers were trained in PBL (oh, how schools love acronyms) and required to design and implement one project for a class that year. The potential benefits of authentic problems that engage students in meaningful thinking and help them to develop useful life skills are great, but the program was not implemented wholeheartedly. When I talked to one of my colleagues at this school a year later, I found out that PBL was no longer being practiced schoolwide. How can we expect to see meaningful improvement when we change from one fad to another every few years? The unfortunate truth is that the work of improving schools is long, arduous, and not at all sexy.

Of all the things that I experienced during that year, the circumstances surrounding my first few weeks of school best illustrate the lesson that schools are complex systems whose components can interact in nonobvious ways to create nonideal learning environments for students. My school district laid off many teachers during the summer of 2009 because of shrinking budgets. Our district has a policy in which displaced (laid-off) teachers are first in line for openings at other schools in the district. This policy is sensible, but because of the size of our district and the large number

of teachers that were displaced that summer, it took months before all of these displaced teachers were rehired and my employment papers could be processed. The first day of instruction at my school was September 10, 2009, but I didn't sign my contract with the district until the 17th. I went to school during those first few days of school even though no students were yet assigned to my classes. September 21 was the first day that I had students in my classes and I didn't get access to class rosters until October 1. Here is a blog entry from that chaotic period.

> Blog Entry 1: Sept. 21, 2009 (Monday)
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> There were 29 students in my third period class today. Hooray! Unfortunately, 30 minutes earlier the assistant principal told me that it was supposed to be an Algebra 1 class and it turned out all the kids were there for Geometry. No problem! I tried not to let my surprise show.
>
> After we got settled, we had a semi-successful discussion on definitions for points, lines, and planes for about 10 minutes. Then I was just about to start an activity involving area and perimeter [when] a teacher came in and took about two thirds of my students to another room. Apparently my class really was supposed to be an Algebra 1 class and these students were going off to Geometry.
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> After the exodus we regrouped, but just as we were about to restart, another teacher came in with new students who were supposed to be [in] the class. By the time we got settled again, there were about three minutes left of class.
>
> I think the thing that bothers me the most is that these students are being subjected to so much chaos. If my own child was in this situation, I would be a furious parent: not just about the fact that almost two weeks of instruction [had] been lost (so far), but that the behaviors and attitudes of students are adversely affected by starting off school in such a chaotic way. I think I will have to work hard to send a message to my students, when I get them, that we are starting fresh.
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> I had no students in two other periods and 20 kids show up in my sixth period Algebra 1 class. I'm thrilled and scared all over again.

I had been looking forward to the scary experience of high school all summer, so it was frustrating to have the year start in this way. But it was much worse for my students. They were shuffled from class to class for weeks, never knowing whether they were going to be in a class permanently or not. Would you take your teacher seriously if you were in this situation? Consequently, it was difficult to establish credibility with my students, and little learning took place in these first few weeks.

Who was to blame for the missed opportunities to learn during these first few weeks of school? Students were incredibly rowdy during this time, as one might expect, but I was also too timid as a new teacher. I delayed teaching the mathematical content of my classes until I had steady enrollments, thereby wasting students' time, even those who weren't ultimately going to be in my class. Our administration's disorganized scheduling also contributed to the mess. I'm not sure one could say that parents were at fault in this situation, although if the school were in a more affluent neighborhood, you can be sure that there would have been many more savvy parents who would have demanded that their children be assigned to the right classes. The district too caused part of the problem because of the way in which my contract was processed. It is important to keep in mind that all of these observations are mine alone—from another observer's perspective the situation would appear very different. No wonder we seem to be at a loss for how to fix our ailing schools.

Lesson 2. Student Self-Concept Is the Best Explanatory Variable for Student Success

I have won teaching awards at the institutions where I've worked, but I intentionally held low expectations for my effectiveness as a high school teacher. Even so, I felt depressingly ineffective as a teacher most of that year. While it's not wise to generalize from a single case, my experience shows that having strong content knowledge in one's field is a necessary but insufficient condition for student learning to take place.

In the education research literature there are some econometric studies that attempt to measure how different variables (district spending per student, parents' education level, past academic performance, training of teacher, students' socioeconomic status, etc.) correlate with student achievement. So, which variables matter most?

According to John Hattie, the variable that correlates most strongly with student achievement is student self-concept. This is a very robust finding. His amazing book [2] synthesizes over 800 meta-analytic research papers on education (thereby covering over 15,000 journal articles!) to determine

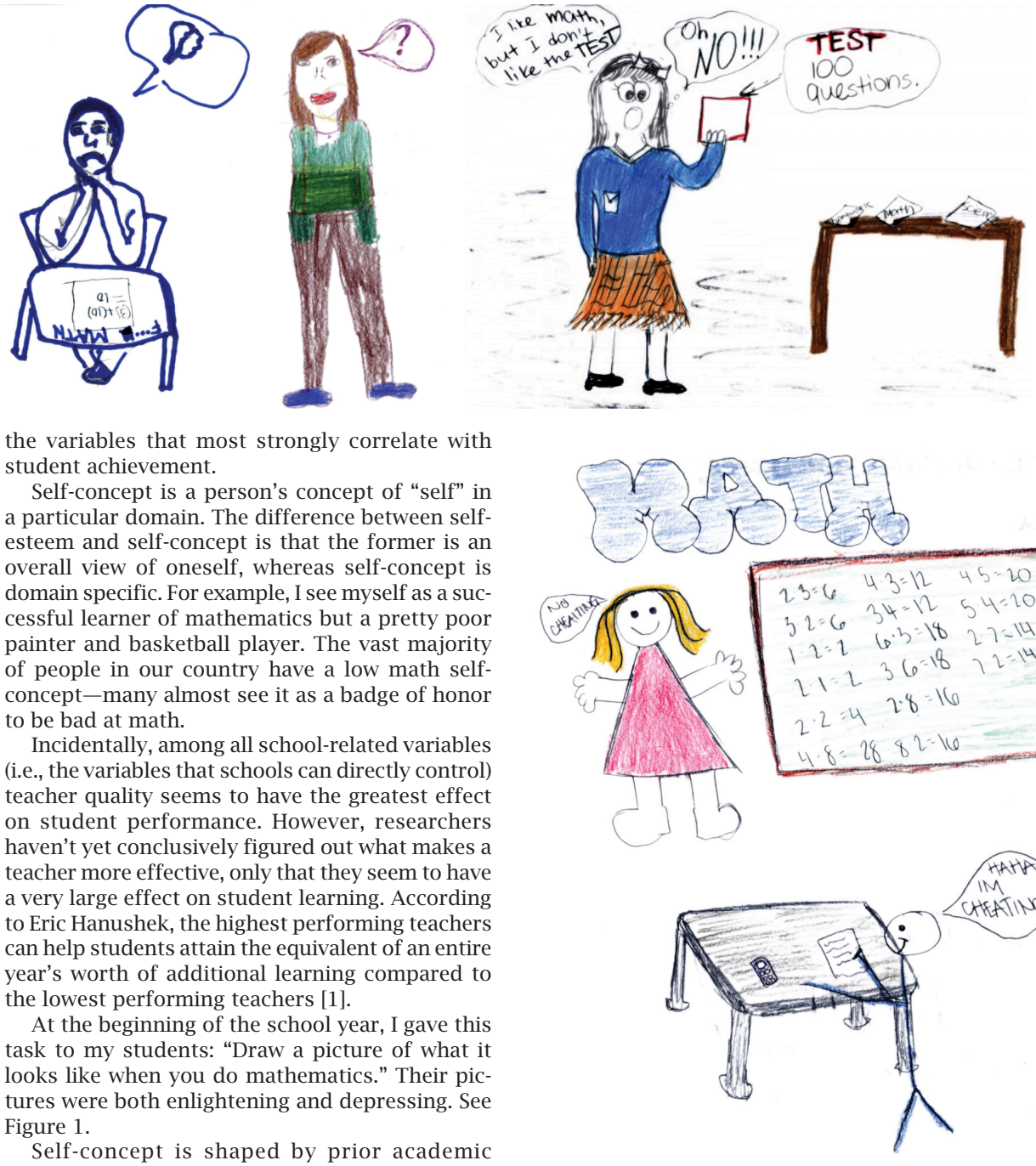

Figure 1.

the variables that most strongly correlate with student achievement.

Self-concept is a person's concept of "self" in a particular domain. The difference between self-esteem and self-concept is that the former is an overall view of oneself, whereas self-concept is domain specific. For example, I see myself as a successful learner of mathematics but a pretty poor painter and basketball player. The vast majority of people in our country have a low math self-concept—many almost see it as a badge of honor to be bad at math.

Incidentally, among all school-related variables (i.e., the variables that schools can directly control) teacher quality seems to have the greatest effect on student performance. However, researchers haven't yet conclusively figured out what makes a teacher more effective, only that they seem to have a very large effect on student learning. According to Eric Hanushek, the highest performing teachers can help students attain the equivalent of an entire year's worth of additional learning compared to the lowest performing teachers [1].

At the beginning of the school year, I gave this task to my students: "Draw a picture of what it looks like when you do mathematics." Their pictures were both enlightening and depressing. See Figure 1.

Self-concept is shaped by prior academic achievement and one's beliefs about who has access to mathematical skill and what it means to be "good" at mathematics. During this year I repeatedly observed that my attempts to make learning engaging (by using fun activities, putting mathematics in contexts that students could relate to, making connections to prior learning) were helpful, but not nearly as helpful as attending to students' self-concepts as learners of mathematics.

If a student's self-concept is based on past academic achievement and future performance correlates strongly with self-concept, how can we break this cycle? I learned that, regardless of how "tough" some students are or how weak their math skills are, teenagers still love feeling successful when they become good at something or when they figure something out. A sequence of small successes can lead students to develop intrinsic motivation to learn and take risks in a classroom. One way to stage these sequences of successes is through minute, detailed, careful scaffolding of mathematics content.

I found that 95 percent of the cases when one of my students was disruptive or seemed

(a)	$x^2 + 8x + 12$	(g)	$x^2 - 49$
(b)	$x^2 - 4x - 12$	(h)	$a^2 + 2ab + b^2$
(c)	$x^2 + 16x + 39$	(i)	$12x^2 - 23x - 2$
(d)	$3x^2 + 9x$	(j)	$x^2 + 10x - 39$
(e)	$2x^2 + 25x + 12$	(k)	$x^2 + 4x + 4$
(f)	$x^2 + 10x + 24$	(l)	$6x^2 + 5x + 1$

Figure 2.

disinterested in learning were the result of the student not understanding what to do or how to do something. Often this happened because I gave poor instructions or because the mathematical tasks that students confronted grew in complexity too quickly or chaotically. Textbooks can frustrate students when they contain sequences of problems that are randomly ordered instead of being arranged by increasing cognitive demand or according to some pedagogical logic. Being able to sequence mathematical tasks well requires knowledge of the cognitive demand of each task, students' prior knowledge of a topic, what students typically find difficult about a topic, and the potential misconceptions that students can develop.

Here's an example to help illustrate this point. Imagine that you are going to prepare a lesson on factoring quadratic polynomials. This is the first time that students will have seen this topic, and you will present a sequence of worked examples on the board to help them understand it. How would you order these 12 quadratic polynomials in your presentation?

After a recent talk on this subject, I had a conversation with a university professor who was adamant that all of these factoring problems are equally difficult: "You just factor them!" For us mathematicians, the cognitive demand required to factor any of these polynomials is so low that all of them are equally challenging. But these problems aren't as easy for students learning how to factor for the first time; some of these examples are more challenging than others. For example, the monic quadratics in Figure 2 are easier to factor than the nonmonic ones. Also, though (c) has a constant term of 39, which is larger than the 24 in (f), many students find (c) easier to factor because 39 has fewer factors than 24. It also turns out that (k) often confuses students because the fact that $2\times2=2+2$ obscures which 4 corresponds to the addition or product of factors. I found that careful sequencing of problems and mathematical tasks matters a great deal.

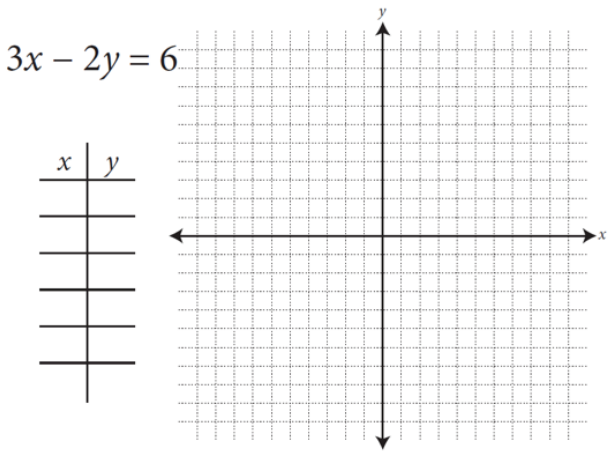

Figure 3.

Another vivid example of these ideas came about one day when my students were solving linear equations such as $3x-4=8$ and $2x-1=15$. Most students were happily solving equations successfully and independently, but one student was off-task most of the class. I walked by many times to offer encouragement and help on the assignment with no effect. Then finally he revealed why he wasn't working: "I don't want to do this, Mister; it's hard."

In a moment of clarity, I brought over another worksheet on graphing linear equations (see Figure 3), something that we had learned the previous week. "Would you like to work on this instead?" The student replied, "Oh yeah, I'll do that; it's easy." He whipped out that worksheet with no complaints. At that point during the year, students had not yet learned to graph lines using slopes or intercepts; they only knew how to make a table of numbers and plot points. Since the coefficients of x and y in the given line $3x-2y=6$ are not 1, the student had to solve for one variable given the other. He was essentially doing the same task as the rest of the class, but he was much more engaged because his self-concept for graphing was higher than for solving linear equations.

As I began to understand the importance of attending to students' self-concept, I noticed my students becoming more engaged in learning mathematics. I initially spent a great deal of time thinking of fun or creative lessons that would get students excited. These lessons rarely worked because they were often too complicated or inappropriate for my students' mathematical development. Instead, I began to design my lessons and accompanying student work so that (1) all of my students could successfully complete the first problem or task independently, and in which (2) the sequence of problems/tasks matched my students' tolerance for challenge and self-concept. This strategy not only increased student learning but also eliminated most of the discipline issues in my class and relieved the pressure of having to develop whiz-bang "fun" lessons every day.

Lesson 3. Teaching Is a Far Less Respected Profession Than It Should Be

Many parents of school-age children will tell you their kids' teachers are great but that "bad teachers" are part of the reason why the school system as a whole is failing. To me, this is one of many indicators of the level of respect that we afford teachers and teaching as a profession. In my opinion, discussions about teacher compensation just scratch the surface. I believe that the deeper issue is that our society, including some people in the school system, doesn't see teaching as a growth-oriented, intellectually demanding career deserving of our nation's best and brightest individuals.

Teachers receive messages every day about how much they are valued as professionals. The way students and parents talked to teachers at our school, the process of signing in and out of work every day, down to the inconvenience of not being given a key to the school office (where the copier was) were examples of such messages. But the most disturbing messages came from the weekly professional development meetings that all teachers had to attend. Here's an excerpt from a blog post describing one of these meetings.

> Blog Entry 2: Feb. 16, 2010 (Tuesday)
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> (2:15 pm) The meeting begins with the assistant principal asking us to write for a few minutes in response to one of these three guiding questions:
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> 1. "What works?" vs. "What is your personal philosophy of teaching?"
>
> 2. How can our school, committed to promoting the understanding of all learners, help teachers contribute significantly toward achieving that goal?
>
> 3. What role does teacher/peer observation play in identifying the underrepresentation of key strategies and processes and existing student achievement and performance gaps?
>
> Wow. Where to begin? First of all, #1 doesn't make any sense. Am I supposed to respond to one question or the other, or am I supposed to respond to the juxtaposition of the two questions? I don't know what the question is getting at and so I have no idea how to respond. Question #2 is such a huge question that I feel completely paralyzed by it. If I am really supposed to answer question #2, I would need more than a few minutes or need the scope of the question to be narrowed down significantly. So, I settle for question #3. I write for a few minutes and then the assistant principal asks us to share our responses.
>
> (2:20 pm) One teacher shares his response to #2. He makes the suggestion that having time in our meetings to share lessons with each other might be beneficial. Another teacher makes the point that it's even better when lessons are shared between teachers from different disciplines. The conversation then devolves into teachers venting about things and whether instituting a protocol for sharing lessons would be helpful or make the process seem too formal. In the end, only one person gets to share a response to the three guiding questions.
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> (2:40 pm) Assistant principal moves us to the next task. We are to read a handout entitled "Investigating the Key Jobs of Teacher and Student," write comments on it, then share our responses within our small groups. Since the handout doesn't have anything to do with the previous three guiding questions or the previous conversation, this action sends (to me, anyway) the message that what we just did wasn't very important. I'm wondering what those three guiding questions were supposed to guide us to. I'm also very curious to see whether the suggestion about having time to share lessons with each other actually gets picked up in future meetings—there have been lots of other suggestions brought up in previous meetings that seemed to get lots of assent but no action.
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> (2:50 pm) The four teachers in my group have been reading the handout silently up to this point. One teacher in our group brings up a question about what to do when all of our students perform poorly on a test. It's an important question, but one that is not really related to the assigned task. Nevertheless, our small group has a discussion on this topic. When the principal asks for the small groups to share their responses, we hear some very general comments about teaching. The handout seems to have had little impact on the discussion.

(3:04 pm) The assistant principal introduces a representative from a local credit union who wants to help us teach students more financial literacy. The meeting ends with some announcements.

Only rarely did I leave one of these weekly professional development meetings feeling invigorated. These were usually meetings in which teachers shared information about the students that we had in common or when the mathematics department met together without an administrator present. Unfortunately, the vast majority of these professional development meetings made me feel as if I had been babysat for an hour. And many of my teacher friends tell me that my experience is not unique.

I recount this incident not to elicit outrage or sympathy, but instead to point out what these professional development meetings say about how teachers are viewed as professionals. Certainly each of us has sat through unproductive committee meetings or workshops. The difference here is that these professional development meetings were mandatory and were the primary mechanism to help us teachers improve our craft. When schools waste this time, teachers are disrespected. When administrators fail to engage teachers with intellectually demanding tasks and questions, the teaching profession as a whole is belittled.

The teaching of mathematics, like mathematics itself, is an endless journey of study. I believe that teaching mathematics can be as intellectually demanding as doing mathematics. If our society could come to see teaching as a job that is emotionally, physically, and intellectually demanding, we would then be able to give teachers the respect they deserve, attract more talented people to the profession, and speed up the pace of pedagogical innovation through the study of teaching.

Lesson 4. It's Not the Written Curriculum That Matters, It's the Assessed Curriculum

Many university mathematicians who take an interest in mathematics education tend to focus on mathematics curricula. For instance, university mathematicians feature prominently in debates about reform versus traditional textbooks that fuel the "math wars". Perhaps the reason for this interest is that textbooks give us an easy way to join conversations about mathematics education. Each of us learned mathematics as children, so feel we have something to contribute to the choice and design of math textbooks. Unfortunately, most of us university mathematicians are very different from the majority of students in our nation who have to study mathematics in high school.

I, too, am interested in mathematics curricula and was excited to teach a range of classes and to use both reform and traditional curricula.

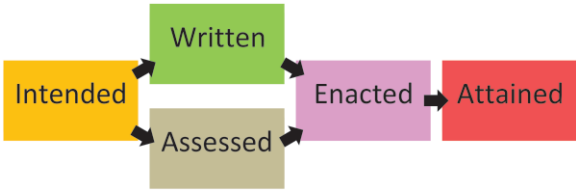

Figure 4. Various meanings of the word "curriculum".

However, at the beginning of that year I greatly overestimated the impact of textbooks on student learning.

The word "curriculum" has various meanings. The intended curriculum comprises state, district, and school standards that dictate what students are supposed to learn and when they are to learn it and, to some extent, how they are to learn it. The new Common Core State Standards are an example of this. Written curricula are the textbooks that schools and districts choose for teachers, but since teachers vary greatly in their adherence to and usage of textbooks, it is important that we pay attention to the curriculum that they enact. All of these lead to the attained curriculum, a construct for what students actually learn.

And then there's the assessed curriculum. I knew little about this concept before my adventure started, but by the end of the school year I became keenly aware of it. Because we live in an era of accountability and standardized testing, my state and district use various assessments to measure how much students have learned. In a perfect world, the intended curriculum would align with the written and assessed curricula, but in practice they often do not agree. When this happens, teachers find themselves in the awkward position of having to decide how to sacrifice one set of learning intentions for another.

My principal was enthusiastic about a reform Algebra 1 curriculum. I was impressed by many wonderful features of this curriculum and wanted to follow it faithfully, but it did not align with our district's periodic assessments. For example, there was a moment during that year when I had to decide whether to teach my students how to blindly follow a recipe to use the quadratic formula (since they weren't yet ready to understand the derivation of that formula) or continue along the path set by our textbook and let them get all of those questions on the periodic assessment wrong. I chose the former and to this day still feel horrible about that decision. Over time I found my teaching becoming increasing aligned with the assessed curriculum: I reorganized the sequence of topics in this reform curriculum and altered how certain topics were introduced or emphasized. This led to a rather weak implementation of the written curriculum and a less coherent Algebra 1 course.

I believe that assessment is crucial to knowing whether students are learning and whether the strategies that schools and districts employ are working. However, we need to remember that these assessments enforce standards for student learning more powerfully than written curricula. While that may not be a bad thing, thoughtful, well-aligned assessments tend to be expensive and labor intensive (both to develop and to grade). And the likelihood of creating and implementing these kinds of assessments is low given the severe financial condition of most states and districts.

Epilogue

As a final illustration of the kinds of frustration that teachers face, here is an excerpt of a letter I received from my school district a few weeks after the end of the school year.

> Dear YONG, DARRYL:
>
> Our records show that you have received an overpayment as a result of a change that was processed in June 2010. The total adjusted gross amount of your overpayment (reduced by any retirement contribution) is $12,197.66. This letter is intended to advise you of your options in repaying the identified overpayment.

The letter was not signed by anyone, there was no contact person listed, and there was no phone number to call! The letter seemed to make it impossible to contest the overpayment; it only listed options for repayment and threatened referral to a collections agency if the amount was not repaid. If I indeed had been overpaid by that amount, I would have earned only roughly $5,000 for the entire school year. I tried calling the district repeatedly but never reached a person who was able to help. It was at this time that I was thankful to be a member of the California Teachers Association. Someone from my local union took on my case and resolved the problem, though it took several months for the mistake to get cleared up.

Many of my colleagues have asked whether I enjoyed teaching high school. Part of me misses the students that I got to know, part of me longs for the chance to try teaching another year at this school so that I can avoid the mistakes that became apparent with hindsight, but another part of me acknowledges that this experience was probably the most challenging period of my career as an educator thus far. So, while I learned and grew a great deal, I can't say that the experience as a whole was enjoyable.

I am, however, very grateful for the experience. I have a much more nuanced respect for high school teachers now. I didn't realize that high school teachers have a far greater potential to affect the course of a young person's life than college professors—this is because teenagers are so fragile and moldable both as young people and as learners of mathematics. This experience has even affected my teaching at Harvey Mudd College. I am more aware of my students' self-concepts now and how that affects their motivation and performance. I use more formative assessment to guide my teaching. My experiences that year gave me new perspectives about my job and informed the way that I think about and work with teachers. Let us all seek first to understand, then to be understood.

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