

## ON MATHEMATICAL CREATIVITY

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What is mathematical creativity?

Forgive me for not answering this question. Better minds have attempted to do so, but no consensus has been reached. I am not confident that a definitive answer will be forthcoming any time soon.

So why ask?

Now this is an interesting question! Perhaps even answerable.

There are those who seek to quantitatively measure creativity in some limited way – but I am not among them. Nor am I convinced that this is a worthwhile endeavor. Of course you will agree with me or not – and I am fairly certain I will not sway you with a few hastily written paragraphs.

We might instead attempt to qualitatively describe mathematical creativity. To what end? Perhaps we might arrange for a team of educators to individually write condensed paragraphs about creativity, but then what is to be done with all the diverse responses? Certainly many such paragraphs have been written already. Consensus is still lacking.

Should I withdraw the question?

Allow me a tentative rewrite. Perhaps, “How might we foster mathematical creativity?”

Much better! But why? We could find an answer potentially useful. Knowing what one teacher did successfully in his classroom could give a colleague an idea which she can adapt for use in her classroom.

Well, this seems to be a promising beginning! A fruitful exchange of ideas, followed by a suitable adaptation, then finally an enthusiastic implementation, and oops! What went wrong?

Learning is situational; teaching is idiosyncratic. From this there is no escape.

Many of us are familiar with the situation where we have two sections of the same class, and what seemed to work wonders in the earlier section is, somehow, not so wonderful in the later section. Perhaps one section was right before lunch, one after. Or a particularly energetic student in one section was sick that day. Maybe a desperate email from a parent just before the later section is lingering heavily on our mind. Rather more likely, however, is just the fact that there are different students in the sections.

Now add to this inescapable fact – that no two classes have the same students – the additional inescapable fact that you are not your colleague. You bring very different backgrounds to your classrooms. Moreover, in creating the lesson, your colleague likely thought through many potential difficulties, then arrived at something he could truly be excited about – and communicated this enthusiasm and confidence to his students in a way which you could not quite match in your classroom.

Nothing went wrong – unless you expected your experience to be the same as your colleague’s. Fortunately, often times it is sufficiently close, but more frequently than we would like, it is not.

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This is simply the usual give-and-take we as teachers experience when we are ourselves creative in the classroom. That a new idea is implemented flawlessly is rare; often many revisions are necessary before we are satisfied with the result. An artist may make several sketches before deciding on a particular composition for a painting. A similar patience is required for artistry in teaching.

This suggests that there is no such thing as a successful curriculum. For success is not derived from the structure of a lesson, no matter how cleverly devised. It should be obvious that teachers must be sufficiently well prepared; but sadly this is often not the case. As I have found from interacting with colleagues from around the world, teachers – especially those working with younger children – have meager backgrounds in mathematics. There is an uneasy tension between insisting that teacher candidates have adequate mathematical experience and the real necessity of having them be certified to teach.

For those of us teaching older students, issues of training in both mathematics and pedagogy are significant. I currently teach at a secondary school for students especially talented in mathematics and science. Some of my colleagues (myself included) had previously taught mathematics at university, while others careers primarily involved teaching at the secondary level. It should not come as a surprise that such diverse backgrounds result in different views on mathematical creativity – and what is needed to foster it.

As an example, I currently teach a course entitled *Advanced Problem Solving*. My approach to fostering creativity? Among other things, I have students write an original problem each week on a topic of their choice.

Now given the nature of the students in this course and the course content, students write problems involving logic, geometry, number theory, probability, recurrence relations, generating functions, and geometrical inversion, among others. I give them relatively little guidance, so that they are free to explore and create. I am moderately successful with this approach.

Would I recommend this approach for a new teacher just out of college? With these topics, I would be hesitant except for the most mathematically proficient teacher.

Does that mean new teachers should forego teaching problem posing until they have more experience? Certainly not. I hope to suggest that my style of fostering creativity in the classroom is intimately related to my background and experience – different teachers will take different approaches. Perhaps more importantly, this particular approach plays to my strengths. And – dare I confess? – I get *excited* about it.

I suspect that every educator knows precisely what I mean. There are courses you teach, and there are courses you are *excited* to teach. Likely there is no need to wonder in which courses your students are more receptive.

*Content is subordinate to engagement.* Again, a few paragraphs will not convince you to favor this position if you do not already – but given my own experience as an educator, I stand by it. I am clearly at my best when both my students and myself are thoroughly engaged in the work at hand...those occasional days when students say, “I can’t believe class is over already!” I wish I had more of them.

The waters muddy. Comparatively speaking, it is easy to teach content to pre-service teachers. But teaching them how to engage their students is a challenge.

Of course this is misleading – is there really a “how” when it comes to engagement? There

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may be many techniques and methods for drawing students in to learning mathematics. But engagement is about *relationship*. And here we confront a fundamental of the human condition – our profound inability to relate to one another.

Perhaps this is an exaggeration, though I might cite any number of large-scale wars as evidence. In the classroom, the student-teacher relationship is the scaffolding of the learning situation. But I am rather at a loss at what more to say.

Do my students laugh in class? What about the student who spent much of the last exam in tears? And what about the student at the table in the corner who never talks to anyone else? Why won't that student come to visit my in my office? Why does this particular student always seem angry? depressed? tired? lonely?

We each handle such situations differently. Teaching is idiosyncratic. But how we relate to our students as human beings ultimately creates our classroom. Imagine, if you can, walking into your classroom and being able to instantly capture the individual responses of your students seeing you walk in. How would you feel?

I maintain that it is *quite* important that students like me as a teacher. I enjoy some moderate success here; I do not think that I am the most popular teacher in my department, but nor am I the least. Students are more likely to be engaged if they enjoy my being in front of the classroom. Of course this is common sense, but a point which I find is downplayed in discussions of curriculum.

Curriculum, pedagogy, content, engagement, relationship. Curriculum can be successfully standardized only to a degree – purposefully vague, but unavoidably so. Here in the US, more colleagues than not (at least among my acquaintances, both at my current and former institutions) are *constrained* by the curriculum they teach rather than *inspired* by it. Is it truly a mystery why our students are not engaged? Currently, a curriculum is seen as a sequential list of topics – complete with learning goals and outcomes – together with a nominally meaningful way to assess whether the outcomes have been met. As this list grows, students become superficially exposed to a breadth of topics, but are never given the opportunity to think deeply about any of them. Perhaps this is because it is difficult to measure depth of thought.

*Measurement drives curriculum.* I need hardly mention the situation in the United States and the infamous No Child Left Behind Act. *Accountability drives assessment.* Of course measurement and assessment need not be the same, but in practice, there is little difference. Simply put, the analysis of the results of standardized assessments is currently the means by which we decide whether our teachers and schools are doing their jobs.

Thus has assessment become political. Parents must be appeased, administrators validated, and legislators satisfied. Of course it is always the children who suffer. By any number of indicators, our educational system is becoming less and less effective. Reasons given for this decline are legion, but there is no need for finger-pointing here.

We imagine that the solution to this dilemma is the ideal curriculum, packaged so that teachers everywhere can deliver the necessary content, with the end result being a sufficiently pleasing number. It matters little what that arbitrary number represents, but that is still what is being sought – *a sufficiently high number*.

It is as though we were training would-be artists by selecting a certain number of classical works of art, turning them into paint-by-number exercises, and then counting the number of

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times students cross over the lines. At the very least, a prospective artist should be able to color within the lines! And so, charcoal in hand (due to limited resources, all work is done in shades of gray), artists of the future are ushered out into an unfriendly world.

At university, everything changes. Colored pencils! Perhaps the student of art is amazed for a brief moment. But only until it is time to learn how to teach younger children how to color within the lines. And, of course, create their own paint-by-number exercises for their own students. Now if I *just* make the lines a little thicker, then more of my students will be able to color within them....

Allow me this poor analogy. Suffice it to say that our educational system does not foster mathematical creativity. The teaching of creativity cannot be standardized, nor can creativity be easily measured (by those who feel so inclined). Thus it has no place in a “curriculum.”

What is required is that we cease to think of education as delivering a curriculum.

So how must we think about education?

I shall certainly disappoint the reader by having no ready answer to this question. Or perhaps not, for any pithy answer would necessarily be glib and certainly be suspicious.

But we might say at least this: *Our classrooms should foster mathematical creativity.* It is a sobering thought to realize that most individuals go through their entire lives without appreciating mathematics as a creative endeavor. I would go further to speculate that most of these think mathematics is nothing more than advanced arithmetic.

The reader will surely be able to supply any number of reasons for why this is the case. Unfortunately, the current legalistic approach to educational reform – an approach centered around standardization, assessment, equity, etc. – only worsens the problem. Such trends essentially serve one purpose: to insulate students from poor teachers. We can no longer guarantee that a student graduating with a teaching degree is competent. Our standards – especially in mathematics – are too low.

Thus the teacher is put on the defensive. Innovation is now suspect, and the impulse toward creativity is dampened. Teach the standard curriculum and have your students pass the standardized tests – or else suffer the very real consequences.

*We must get students excited about learning mathematics.* Force-feeding content to unmotivated students simply doesn’t work.

*We must get teachers excited about teaching mathematics.* The enthusiasm a teacher has for teaching mathematics is communicated to her students.

*We must foster creativity in our classrooms.* This is not an answer to a particular question, but rather a focusing point for conversation about pedagogy.

*We need a paradigm shift in the way we think about curriculum.* As technology develops, the ways students learn and students’ attitudes toward learning change much more rapidly than our teaching strategies do. Yet the current approach toward curriculum emphasizes standardization and homogeneity, when in fact more flexibility is needed. Technology develops more quickly than standards change, so that much of what we teach students to be able to do by hand can be accomplished with a few keystrokes. It may be the case that most students, after they graduate, will rarely perform a mathematical calculation by hand. We simply cannot ignore this sobering fact.

So there is much work to be done. A teacher whose primary focus is to be creative,

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spontaneous, and engaging in the classroom is a very different teacher than one whose primary focus is to prepare students for a standardized exam. We must radically change the way we train teachers, and we must make teaching a more attractive profession for our especially talented students. We must acknowledge that our current way of thinking about curriculum and pedagogy is not adequate in our technologically advancing world – and find alternate, workable perspectives.

I shall not end with a few hopeful platitudes – frankly, the situation is not really hopeful at all. Education might be about empowering students to create their own *Starry Nights*, or teaching them to color within the lines of paint-by-number imitations. Which shall it be?