5 Barriers to Spreading Joyful Mathematics

And how to overcome them

Scott Kim, February 2024

In his Aug 1998 article "A Quarter-Century of Recreational Mathematics" in Scientific American magazine, Martin Gardner wrote

> *For 40 years I have done my best to convince educators that recreational math should be incorporated into the standard curriculum. It should be regularly introduced as a way to interest young students in the wonders of mathematics. So far, though, movement in this direction has been glacial.*

Martin Gardner was a hero to me and many other budding mathematicians. He opened the door to the joys of mathematics for more people than anyone else in history. So to hear him despair at his inability to influence educators is sobering.

But not unexpected. All of us here understand the deep joy that doing mathematics can bring. And we love sharing that joy with others. But if you ever tried to bring that joy into schools, you know how resistant schools are to change.

And it's not just schools. Society at large is stubbornly mathphobic. If you tell someone at a party that you are a mathematician, you will hear stories of pain, embarrassment, and fear.

As Justin Reich chronicles in his book "Failure to Disrupt," education reformers have tried and failed to budge the school system for over a century. Every new technology, from television to VR, has been touted as the thing that will change schools forever. They've all failed to make progress because education is not a tech issue; it's a social issue.

So, if we want to spread joyful mathematics and change attitudes at a societal scale, we need to understand what we're up against to figure out what new actions we need to take.

In this article, I'll break down the barriers to the widespread adoption of recreational mathematics in education and discuss what it will take to overcome them.

Recreational Mathematics

Regarding recreational mathematics, Gardner writes:

The line between entertaining math and serious math is a blurry one. In general, math is considered recreational if it has a playful aspect that can be understood and appreciated by nonmathematicians. It encompasses mind-bending paradoxes, ingenious games, and bewildering topological curiosities such as Möbius bands and Klein bottles.

Gardner gives several examples of the playful mathematics he featured in his Mathematical Games column, which ran from 1956 to 1981. Check out the original article for details. His examples include

- A **magic trick** involving a matrix of numbers — understanding why you always end up with the same sum involves a surprising moment of insight.
- A notorious **paradox** that has been dubbed the Monty Hall problem — it's not a logical paradox but rather a crisis of intuition, where a seemingly simple probability problem sparks fierce debates, even among mathematicians.
- A classic 3D **puzzle** called the Soma Cube, invented in 1933, is in which 7 pieces must be assembled to form a 3x3x3 cube or other interesting shapes. It's a perenially popular toy enjoyed by kids and adults alike.

These experiences have four qualities that set them apart from typical classroom exercises:

- **Entertaining**. All these experiences hook the audience with a riveting premise that keeps you on the edge of your seat. In contrast, typical classroom experiences give you little reason to care other than "it will be on the test."
- **Exciting**. These experiences evoke curiosity, awe, and excitement — emotions which open you up to learning. Typical classroom experiences evoke boredom, anxiety, and fear of failure.
- **Participatory**. Curiosity leads naturally to classroom discussion, where students are eager to understand what is happening. Conventional math education overexplains what you are supposed to learn, leaving no room for natural curiosity or divergent opinions.
- **Approachable**. Finally, these experiences never overload the audience with difficult prerequisites. The elements of the problem are familiar and easy to understand. In the case of the Soma cube, the pieces are physical, making them pleasurable to touch and handle.

Together, these four qualities make magic tricks, paradoxes, and puzzles ideal ways to engage learners at the start of a lesson. Teachers are rarely trained in the art of creating captivating experiences, but as every teacher knows, their first responsibility is to engage the students' attention.

Now, let's look at the five barriers to the widespread adoption of recreational mathematics.

1. Lack of Exposure

Barrier: most people have never been exposed to joyful mathematics. That includes both students and teachers. Their only experience of mathematics is through school, and most of that is boring, anxiety-provoking, and meaningless. When older kids and adults finally experience joyful mathematics, they are often pissed — why didn't I know this sooner?

Solution: This is the most basic barrier, and it's the easiest to overcome. We must create more joyful mathematics experiences and get them in front of kids.

That's what the Julia Robinson Math Festival is doing with its in-school festivals and what the Museum of Mathematics in New York City is doing with its museum and many outreach programs for kids and adults. It's what Thinkfun is doing with its wonderfully designed puzzle toys for families and books like The Number Devil, and You Can Count on Monsters are doing for young readers.

Which leads us to...

2. Lack of Distribution

Barrier: we need to reach more people, especially those scared off by the word "math."

Solution: distribute through the most widely viewed channels, like YouTube. And use language and presentation styles that appeal to people who don't like math.

The most successful example of excellent distribution for an inventive educational experience is Sesame Street, which exploded on public television in 1969.

These days, math YouTubers like Grant Sanderson of 3 Blue 1 Brown and Derek Muller of Veritasium are making a serious dent in math education by producing seriously entertaining and highly personal videos on deeply mathematical topics.

YouTuber Vi Hart has done an outstanding job of reaching young women who don't love math by leading with a voiceover about how boring math class is.

But much great recreational mathematics needs better distribution. I recently hooked up with Alex Rosenthal at TEDed, which has produced a spectacular video library of over 100 mathematical riddles. With over 19 million subscribers, they have certainly reached a large audience. But like many nonprofit educational institutions, their funding is used primarily to pay their small staff, which means their beautifully produced material is less well known than it should be.

I think the lack of attention to distribution and marketing stems from the fact that teachers teach to a captive audience and thus don't have to market themselves. In contrast, the market forces on YouTube, where everyone competes for the viewer's attention, force content creators to design videos that hook and hold the viewer's attention — the best YouTube math videos tell great stories.

Next, we have the active barriers — forces that actively resist change.

3. Mental Model of Math

Barrier: if you believe the narrow definition of mathematics taught in school, you will reject anything playful as "not real mathematics."

Solution: widen people's understanding of what mathematics is.

When I take math games into classrooms, students and teachers have a good time and generally understand the value of what they are experiencing. But then, class goes back to "normal". Teachers treat recreational mathematics as a brief break from real mathematics rather than an integral part of good education.

The underlying reason for this disconnect is that school trains people to believe that mathematics consists only of memorizing and accurately reproducing

canned formulas. Under that definition, any experience that involves ambiguity, asking questions, or creativity does not qualify as mathematics.

A similar situation once existed in English class. When I went to elementary school, I learned the rules of grammar and how to write an outline before writing a paper. Completely missing from this curriculum are the much messier things that real writers do — searching for topics, drawing mind maps, and most importantly rewriting. Thank goodness school now teaches the complete writing process, through programs like the widely adopted Readers and Writers Workshop programs, published by Heinemann.

We need to do the same for mathematics. And indeed, Heineman also publishes a "cognitively guided instruction" math program with the same philosophy as Readers and Writers Workshop. Doing math is more than memorizing formulas and computing correct answers. Doing math also includes noticing patterns, being curious, asking questions, trying things out, being wrong, and trying again. Under that much broader definition of mathematics, everyone is already a mathematician.

4. Curriculum Standards

Problem: curriculum standards leave no room for recreational mathematics

Solution: revise the standards and build recreational mathematics into the core curriculum.

Teachers resist including more recreational mathematics in their teaching — even the ones who love it — because they don't have time. Teachers are under increasing pressure to stick to state-mandated curriculum standards that prescribe precisely what to teach, and when. As a result, teachers race through a curriculum that is "a mile wide and an inch thin", without pausing to make sure that kids understand what they are learning.

California — often the leader in social change — is now embroiled in a highly contentious effort to revise state math curriculum standards. Parents and teachers are wary of new standards, and for good reason — every math reform I've lived through has been royally botched. For instance, the recent Common Core standards were originally drafted by state legislators who had no expertise in education (educators swooped in to triage the damage), and implemented without any funds or plans for producing revised textbooks or retraining teachers.

To move things forward, we need successful examples of progressive mathematics education that meet accepted standards. I'd like to see radically different approaches to teaching math that produce twice the results in half the time, with greater engagement and retention.

Finally, we come to the most stubborn barrier of all.

5. Societal Norms

Barrier: the widespread belief that math is a painful subject that must always be taught in the same way.

Solution: start a social movement that lets people heal math abuse and reclaim mathematical empowerment.

Math anxiety is a generational trauma passed on from one generation to another by parents and teachers who never learned to love math when they were kids. Math empowerment needs to become a society-wide movement. People need to heal from mathematical trauma, reclaim their right to a healthy relationship with mathematics, and know that mathematics can be joyful.

This movement is already happening with STEM, but somehow, math gets left out in the excitement of promoting science, technology, and engineering. M may not be as obviously flashy as STE, but you can't have STE without M.

Starting a social movement is a grassroots effort that requires many leaders. I look to other examples of social change movements, like abolishing slavery and allowing women to vote, for inspiration. Within education, society already transformed literacy from a skill possessed by a few scribes to a skill enjoyed by the entire population. We can do the same for math.

Don't be discouraged by the scale of the problem. Instead, be energized by the scale of the opportunity. As Margaret Mead once said, "Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has."