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Math that feels good:

A model for math education reform

This summary was prepared by ***George Gadanidis***, ***Janette Hughes*** *and* ***Immaculate Namukasa*** *who are co-investigators on a 2016-2019 Social Sciences and Humanities Research Council (SSHRC) Insight Grant on* Aesthetic Experiences for Young Mathematicians & their Teachers.

What is this research about?

This research addresses two important issues in math education: (1) How do we help students experience and share the beauty and pleasure of math? and (2) How do we engage teachers in math reform that is personally and professionally meaningful and rewarding?

We know there is a long-standing problem with school math. For generations, young children have entered school mathematically curious, enthusiastic and capable (Papert, 1980) only to develop as adults who typically dislike and avoid the subject. As educators and as education leaders we have done our best to change this cycle, to improve on our society's pervasive negative image of math, but it persists.

What you need to know:

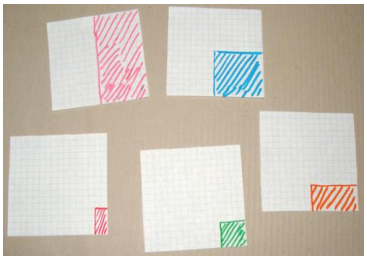
Although reform is typically associated with change on a grand, pervasive scale, our model is much less intrusive pedagogically. We do not seek a revolution -- we don't seek to change everything at once -- but to occasionally and strategically focus on math worthy of attention, worthy of conversation, worthy of children's incredible minds.

Perhaps society has become immune to adults (or *just* adults) trying to fix this problem. Perhaps it is time to give children a chance to make a difference, by sharing with us the inherent pleasure of mathematical surprise and insight, so that we may then appreciate its beauty and even share it with others!

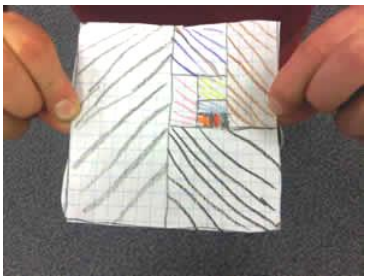
When was the last time you were surprised mathematically? When was the last time you said to someone, "I learned this really cool math idea. Let me tell you about it"?

We don't seek to change everything at once, but to occasionally (say once per unit of study) and strategically focus on math worthy of attention, worthy of conversation, worthy of children's incredible minds. And we want to do this by empowering teachers, by starting with topics that they themselves identify as areas of interest or need.

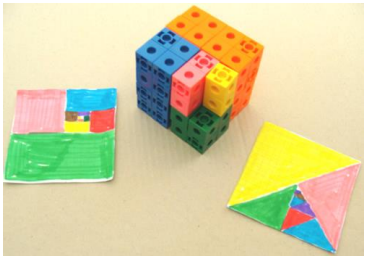
What did the researchers do?



Over the last ten years, funded by SSHRC, KNAER and the Fields Institute, we have been working in K-8 schools in Ontario and in Rio Claro, Brazil, designing experiences that offer students (and their teachers and parents) the pleasure of math surprise and insight. We have also been developing an effective model of math education reform that addresses teachers' interests and needs.



Working with teachers we ask what they need help with in their math teaching. For example, when three grade 3 teachers in a school in Whitby told us they were looking for new ideas for teaching "area representations of fractions", we co-designed the activity below to (a) cover the grade 3 curriculum, but (b) also to offer a math surprise.



1. Can you walk out the classroom door? When students replied "Yes!" the teacher invited a volunteer to walk half the way to the door, then half of the remaining distance, then half of the remaining distance, and so on. How can we walk past the door when there are an infinite number of steps to get to the door?

2. Area representations of fractions. Using 16x16 square grids, students represented the first 5 steps to the door as the fractions 1/2, 1/4, 1/8, 1/16 and 1/32.

3. Putting fractions together. Using scissors, students cut out the shaded parts. The teacher asked, "If you do this forever, shading fractions to represent the steps to the door, then cut out and join the shaded parts to form a new shape, how big would that new shape be?"

4. Infinity in my hand! Students noticed that all the fractions fit in one of the original 16x16 squares, which means it's possible to hold infinity in one hand! They then explored a variety of different ways to shade or build this pattern.

5. Sharing at home. Students worked in small groups to summarize their learning and to script dialogues they might have at home, to share what they learned in ways that would surprise their parents. Here is a part of an at-home dialogue written by a group of Grade 3 students in Canada, which later became a song:

Hey Serena do your chore, take the garbage out the door.
I can't Daddy, I learned in math, I can't do it any more.
It can't be true Serena, your teacher is crazy.
You can walk out the door, you've done it many times before.

And a song written by Grade 2 students from Brazil (translated to English), which they performed for their Grade 4 peers, as well as for their parents at a math event organized by the school:

Infinity

Infinity, little infinity, let's all learn
Let's think about what it is and what size it has
I can see its beginning, but the end I can't
If I try to reach the end
I will see that it never ends
But I can hold infinity in my hands
1/2, 1/4, 1/8 and so it goes
It's all cool, it never gets out of a square

6. Sharing with a wider audience. We used data from student thinking and parent comments to create songs and artwork to be shared publicly, along with classroom documentaries. See researchideas.ca/wmt/c1b5.html for a video of Bob Hallett of *Great Big Sea* and Aboriginal recording artist Tracy Bone performing the at-home dialogue above as a song. We donate the research-based artwork we create to schools we work in. The painting below, which captures the gist of the above activity, is hanging at a school in Whitby, Ontario.

In this activity, students had ample opportunities to investigate and practice area representations of fractions. They also had opportunities to engage with the concepts of infinity and limit (which they will encounter again in Calculus) and to share their learning--their math surprises and insights--with a wider audience.

We have developed a variety of similarly rich contexts (using linear functions, sequences and series, non-Euclidean geometry, and so forth) as pedagogical wraps for mandated curriculum content for young grades--see researchideas.ca/wmt.

Occasional, well-designed mathematics experiences "that are immersive, infused with meaning, and felt as coherent and complete" (Parrish, 2009, p.511), and the associated experience of complex, surprising, emotionally engaging, and viscerally pleasing mathematics, can serve as "a process of enculturation" (Brown, Collins and Duguid, 1989, p. 33) with lasting impact on students', teachers' and parents' dispositions, living fruitfully in future experiences (Dewey, 1938) by raising expectation and anticipation of what mathematics can offer.

What did the researchers find?

The occasional wrapping of complex and surprising math ideas around curriculum expectations creates interest and excitement for mathematics in the classroom and at home. The response from parents has been consistently positive. For example:

> "I was surprised how advanced the math exercises were and how so very easily my son grasped it all."
>
> "It's amazing that they're learning this math in grade 3. I thought she couldn't do it but she really did. I hope you give more homework like this."
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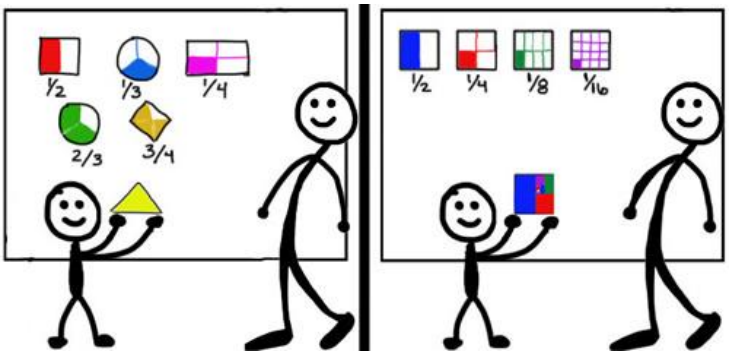
> "It's great to see my son excited about school and about math."



> "I found school math hard, so I loved to watch her excitement, and her complete understanding and explanation of it all."

How can you use this research?

Several of the activities we have co-designed with teachers are available at researchideas.ca/wmt-- try one in your classroom. As well, at researchideas.ca/sidebyside, you will find some of the activities offered side-by-side with more typical approaches to the same curriculum content, providing opportunities to try both approaches with your students--to engage with mini research activities--and compare and contrast how students and parents respond.

Original research article:

This snapshot summarizes the article:

> Gadanidis, G., Borba, M., Hughes, J. and Lacerda, H. (in press). Designing aesthetic experiences for young mathematicians: A model for mathematics education reform. *International Journal for Research in Mathematics Education.*

About the researchers:

George Gadanidis, **Janette Hughes** and **Immaculate Namukasa** are co-investigators on a 2016-2019 SSHRC Insight on the above theme. Previous (2006-2016) research in this area was funded by SSHRC and KNAER and outreach funded by the Fields Institute. Gadanidis and Namukasa are Mathematics Education professors at Western University. Hughes is Canada Research Chair in Technology and Pedagogy at UOIT.

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Keywords:
Elementary school mathematics; math surprise; math insight; math reform

About this summary

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