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WHAT WORKS? *Research into Practice*

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Research Monograph #56

How can we improve motivation, interest and attention in the elementary mathematics classroom?

Making Math Children Will Love: Building Positive Mathitudes to Improve Student Achievement in Mathematics

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Many students dislike classes in mathematics. In Ontario, the Education Quality and Accountability Office (EQAO) tracks student attitudes toward mathematics, noting shifts in percentage points from year to year but indicating overall that significant numbers of children in Grades 3 and 6 do not like this important subject.[1] Complementary research suggests consensus regarding the reasons for this widespread belief – from the elementary child's perspective, mathematics is hard, boring, mostly irrelevant and unrewarding.[2,3]

EQAO survey data also highlight that proportionate numbers of children (and fewer girls) do not believe that they are good at mathematics, or that they can "do" mathematics. Students' beliefs are correlated to their attitudes about, and achievement in, mathematics; if these dispositions are negative, learning is impeded and academic success is limited. In contrast, when students are positive about and engaged with mathematics, they are more motivated to learn (even from mistakes), accept new ideas and try more challenging tasks. This, in turn, leads to the development of improved self-esteem, confidence, perseverance, creativity and performance.[4]

Evidence suggests that learning is energized by affect. We, as educators, must turn our attention to resources and strategies that improve students' relationships with mathematics content and processes and pique students' motivation, emotion, interest and attention. Multiple non-traditional activities and attention-grabbing resources can spark curiosity about mathematics, improve appreciation for and interest in mathematics and contribute to understanding the relevance of mathematics in everyday life. In these ways, we may impact how mathematical knowledge grows and connects and, thus, improve achievement scores.

Research Tells Us

- Negative attitudes wield significant and adverse influence on students' motivation and ability to learn and do mathematics.
- It is never too early to nurture the growth of a positive disposition towards mathematics, and improve the relationship that children have with mathematics content and processes.
- Teachers can improve student achievement by turning their attention to resources and strategies that pique students' motivation, emotion, interest and attention.

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Loving the Math!

"Instead of trying to make children love the math they hate, make a math they'll love."

– Seymour Papert[11]

Mathemagic: Number Tricks
www.kidscanpress.com/canada/Mathemagic-P5941.aspx

The Prime Radicals Shows
www.tvokids.com/shows/primeradicals

The Prime Radicals Games
www.tvokids.com/games/primeradicals

The Prime Radicals Pentomino App
http://www.tvokids.com/apps/primeradicalspentominos

The Prime Radicals Snowflake App
http://www.tvokids.com/apps/primeradicalssnowflakes

The Power of Mathematics Play

We know that learning often begins with play. Children learn about fluids and buoyancy by "doing the dishes" at the kitchen sink. Similarly, they learn geometry through play about space and shape, forming visual templates of shape categories (e.g., they come to recognize a shape as a rectangle because "it looks like a door"). As children move beyond the early years, they continue to have many opportunities, often outside school hours, to learn through planned play environments in which learning opportunities are deliberately embedded. Fun is a common characteristic of informal educational experiences, which might include wandering through museum installations and learning about science, technology, engineering, and mathematics (the "STEM" disciplines), watching television programs such as *Bill Nye The Science Guy* or experimenting with aerodynamics by folding paper airplanes engineered from the *Klutz Book of Paper Airplanes*.

At their core, experiential learning activities in informal contexts, actual or virtual, are designed so that when children play, engage, explore, or interact, they cannot *not* help but learn science and mathematics because they are doing science or mathematics.[5] Further, initial curiosity in science or mathematics has the potential to evolve into genuine interest. The "wow" factor that first captures a child's attention is likely to contribute to the development of greater understanding of, and positive attitudes toward, mathematics and science.

Engaging Tools in the Classroom

In general, play and experiential learning in multiple contexts connect deeply with children's passions and interest, making learning profoundly personal. By adopting engaging tools in the classroom, teachers may be able to transform feelings about learning and mathematics by changing the focus from teaching facts and skills to building positive relationships between children and mathematics. The way that children feel about mathematics profoundly influences what they do with it and how they reflect on it, which in turn influences how knowledge grows and connects.[6]

Educational Television

Viewing math-based educational television programs can evolve into interest in the underlying mathematics and contribute to the development of greater interest and positive attitudes.[7] When children become fans of television programs, they spend more time engaged in enjoyable, non-explicit mathematics learning without even knowing it. This contributes to a positive attitude and, eventually, advances content knowledge.

One such program, *The Prime Radicals*, broadcast provincially on TVO and supported by TVOKids and TVOParents, is a multi-media mathematics television program, targeted at elementary students. This 15-minute program airs twice weekly on TVO and can be streamed from the TVOKids website (see sidebar). Each of the episodes features "Uncle Norm" (always in problematic situations), a robot called "The Inventonator," and two cousins, "Alanna" and "Kevin", who always save the day by using mathematics. *The Prime Radicals* website complements the series with interactive games and puzzles, based on the same mathematical content as the television series. Further, the series offers outreach materials designed to engage children in hands-on math activities based on the television programs. A wide inventory of print and multimedia materials –

including math craft instructions, songs, and game apps related to specific episodes – are freely available along with curriculum correlations.

Sustained viewing of educational television series, like *The Prime Radicals*, can produce a significant impact on both the process of children's mathematical problem-solving and the sophistication of their solutions. These effects are found most consistently when teachers generate complementary tasks taken directly from television episodes that the children have viewed. The following example suggests one such task:

GETTING STARTED (15 minutes)

As a class, watch *The Bunnies' O.K. Corrall* episode. Using the real-world context of constructing an outdoor pen for pet rabbits, this episode focuses on the relationship between perimeter and area and illustrates that 2D shapes with the same area can have different perimeters.

WORKING ON IT (30 minutes)

- **Part 1:** Using sixty, 2-cm square tiles and one sheet of 2-cm square grid paper, challenge students to find as many pentomino shapes as possible (tiles must be fully connected). Invite students to compare their figures in small groups, discovering the twelve unique pentominoes.
- **Part 2:** Display the figures on the interactive white board and, as a class, calculate the area and perimeter of selected figures. Students then continue the task for all twelve figures, learning that all figures have areas of 5 units^2 and, with the exception of the "P" pentomino, all have perimeters of twelve units.

CONSOLIDATION AND PRACTICE (25 minutes)

Invite students to play *The Pentomino Game* (see sidebar) to investigate the greatest perimeter of a combined figure with two pentominoes; the greatest perimeter of a combined figure with six pentominoes; and, using all the pentominoes, how to create the combined figure with the greatest perimeter.

Magic Books and Other Kinds of Vivid Texts

Narrative structures help children to develop the confidence to undertake a new learning activity or to venture into an unfamiliar intellectual domain, such as mathematics. Among the most vivid texts are those that contain rich imagery, suspense, engaging themes and tantalizing information that engages the reader.[8] The challenge is to find texts with two qualities: compelling narratives that offer both explanations of content and characters who model successful approaches to problem solving; and participatory, interactive and hands-on narratives that provide opportunities for children to practise these skills. Magic books are popular in the world of children's literature for these reasons. As anyone who has ever watched a magic show will testify, the response to many tricks is often the question, "How did he or she do that?" Initial amazement turns to curiosity. With appropriate support, curiosity can become systematized and transformed into a gateway to knowledge and the discovery that incredible things are explainable.

One non-fiction example designed for Grades 4 to 8 is *Mathemagic: Number Tricks*.[9] *Mathemagic* uses the context of magic tricks, performed by a young female "mathemagician," to bring mathematics to life by appealing to children's curiosity. Through sleight of hand and some basic mathematics concepts, students learn to perform engineered tricks involving seemingly impossible "mind-reading" acts or rapid computations. The focus

Have Fun with Math! ...

"... games and play have more positive effect on motivation and retention of knowledge than conventional instruction."

Jonnavitula and Kinshuk[12]

Looking for resources?

Queen's Community Outreach Centre Resources for Teachers and Parents
http://educ.queensu.ca/coc/resources

of *Mathemagic* is to reveal the secret behind the trick, where explanations include manipulative-based algebra and factor trees. By focusing on little-known inventions, such as "Napier's Bones" and "Lucas-Genaille rulers" (to perform multiplication and long division, respectively), and legitimizing strategies that use the fingers to solve computational problems or multiply multi-digit numbers using the principles of binary arithmetic, the book brings both history and imagination to mathematics learning.

The *Mathemagic* activity below might engage your students in finding their most important role model:

- Prepare a list, numbered 1 through 10, of possible role models. (Note: This activity can be adapted to many different topics and themes, such as favourite food, colour, hockey player, etc.)
- Without looking at the list, have students choose their favourite number between 1 and 9.
- Ask students to multiply their chosen number by 3, then add 3 and multiply again by 3 (each student's result should be a 2-digit number).
- Have students add these two digits together and use the results to find their role model on the prepared list.

Mathemagic supporters state, "The best way to teach math is to help [children] to learn something that they enjoy showing to people. If they're having fun, they own the experience."[10]

In Sum

Ontario students are sending a loud and clear message – they are telling us they don't feel confident in math, they don't think they will do well in math and they don't like math. Children's discomfort with math must be of concern, and we must work together to build mathematics positivity because the research is clear. Before children can learn mathematics, they must become interested in it. As Koirala notes, "If kids are not having fun, they're not going to commit themselves. They're not going to practice or learn. Fun generates achievement and focus."[10]

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