Facilitating Algebraic Thinking Development with Appropriate Tools and Technology

Presented by
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at the
National Council of Teachers of Mathematics
Annual Meeting and Exposition
San Francisco, CA
April 2016

CURRICULUM & INSTRUCTION
School of Education
BAYLOR UNIVERSITY

Is Algebra for Everyone?

YES!

Algebra is primarily a method of thinking and ……

"thought, thinking processes, and the ability to appreciate mental accomplishments are the rightful possessions of every individual."

John P. Everett, NCTM President in 1932

Let's Discuss

- What is algebraic thinking?
  - Discuss with people around you/at your table
  - Share with whole group
- What sort of tasks promote algebraic thinking?

NCTM Research Brief: Algebraic Thinking in Arithmetic

"algebra eyes" (Subramaniam & Banerjee, 2011)

1) thinking relationally about equality
2) thinking rule-wise in pattern generalization
3) thinking representationally about the relations in problem situations

Developing Essential Understanding of Algebraic Thinking (Grades 3-5)

Big Idea 1. Operations and Arithmetic as a Context for Algebraic Thinking

Big Idea 2. Equivalent Quantities and Equations

Big Idea 3. Variables

Big Idea 4. Quantitative Reasoning

Big Idea 5. Functional Thinking

(Blanton et al., 2011, NCTM)

Developing Essential Understanding of Expressions, Equations, and Functions (Grades 6-8)

Big Idea 1. Expressions

Big Idea 2. Variables

Big Idea 3. Equality

Big Idea 4. Representing and Analyzing Functions

Big Idea 5. Solving Equations

(Lloyd et al., 2011, NCTM)

Developing Essential Understanding of Functions (Grades 9-12)

Big Idea 1. The Function Concept

Big Idea 2. Covariation and Rate of Change

Big Idea 3. Families of Functions

Big Idea 4. Combining and Transforming Functions

Big Idea 5. Multiple Representations

(Cooney et al., 2010, NCTM)

Let's Discuss

- What are the essential elements to consider for effective use of technology?
  - Discuss with people around you/at your table
  - Share with whole group

NCTM Position Statement
Strategic Use of Technology

- regular access that supports and advances
  - mathematical sense making,
  - reasoning,
  - problem solving, and
  - communication

- optimize the potential of technology to
  - develop students' understanding
  - stimulate interest
  - increase proficiency

- provide greater access to mathematics for every students

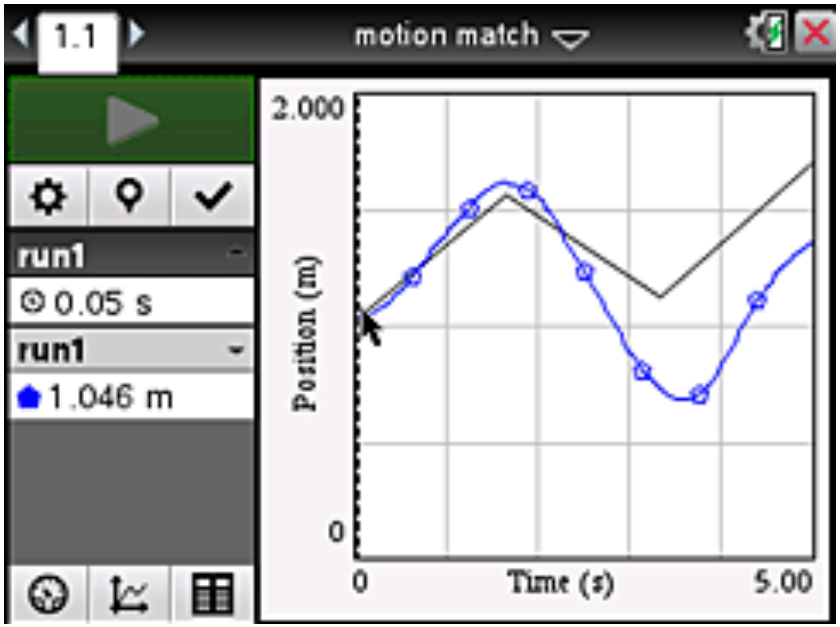
http://www.nctm.org/Standards-and-Positions/Position-Statements/Strategic-Use-of-Technology-in-Teaching-and-Learning-Mathematics/

Mathematics Teaching Practices

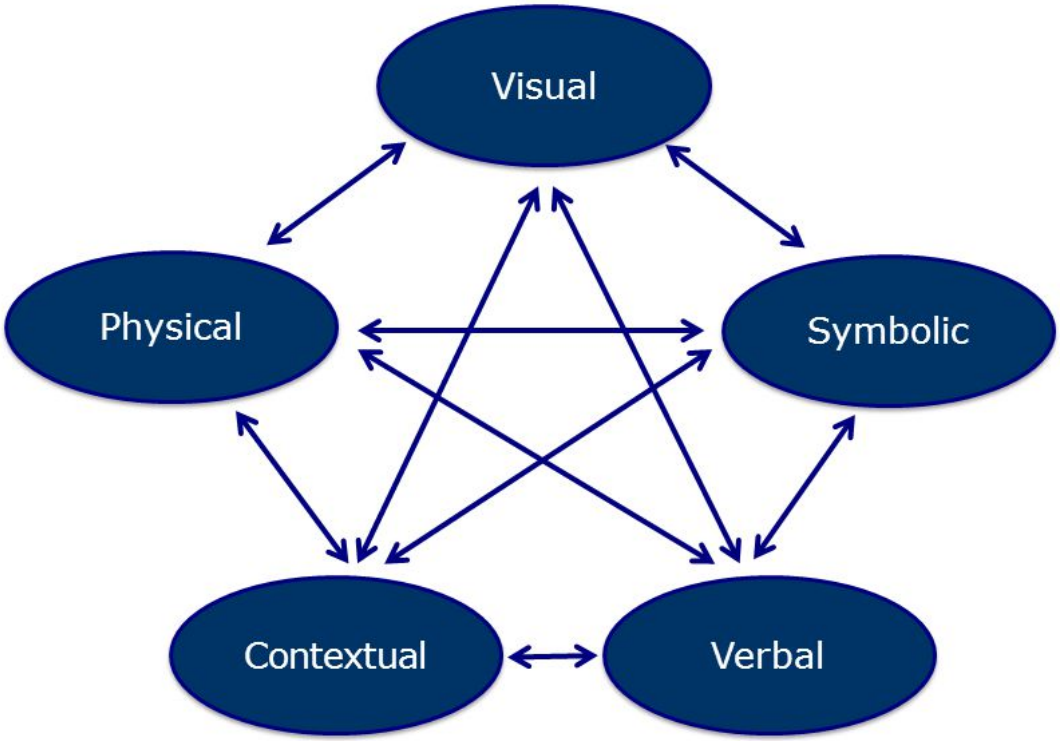
1. Establish mathematics goals to focus learning.
2. Implement tasks that promote reasoning and problem solving.
3. **Use and connect mathematical representations.**
4. Facilitate meaningful mathematical discourse.
5. Pose purposeful questions.
6. Build procedural fluency from conceptual understanding.
7. Support productive struggle in learning mathematics.
8. Elicit and use evidence of student thinking.

(NCTM, PtA, 2014, p. 10)

Technology Tool 1: CBR (Calculator Based Ranger)



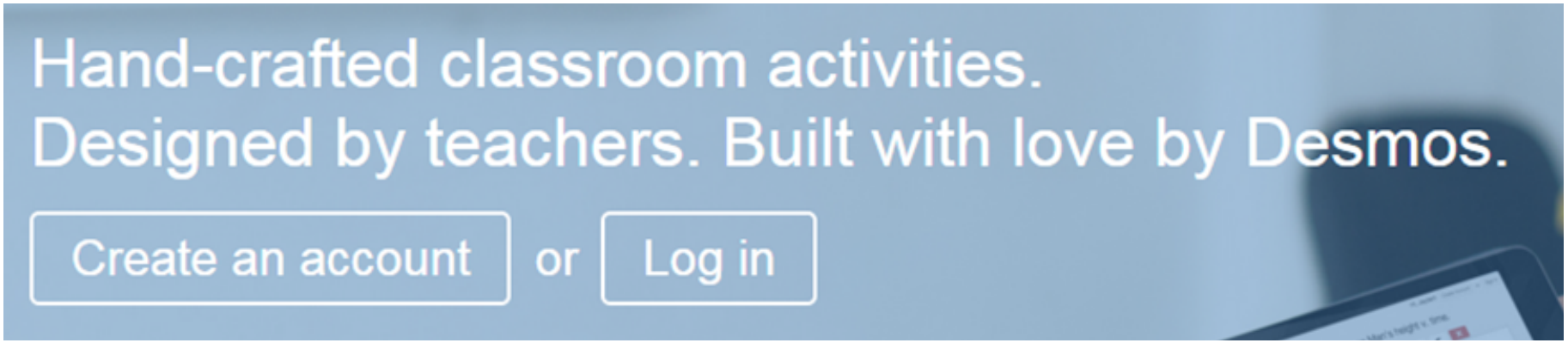
Use and Connect Mathematical Representations



adapted from (Lesh et al., 1987 (NCTM, PtA, 2014, p. 25)

Technology Tool 2: DESMOS Polygraph

teacher.desmos.com



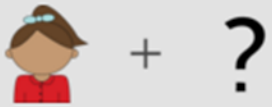
How Polygraph works:

1. Practice

Each student plays a practice round against the computer to learn how the game works.

2. Play

Next, students are paired with a classmate to play polygraph with graphs. One person chooses a graph; their partner asks yes/no questions in order to narrow a field of suspects down to one.



3. Reflect

Between rounds, students answer questions that focus their attention on vocabulary and strategy.

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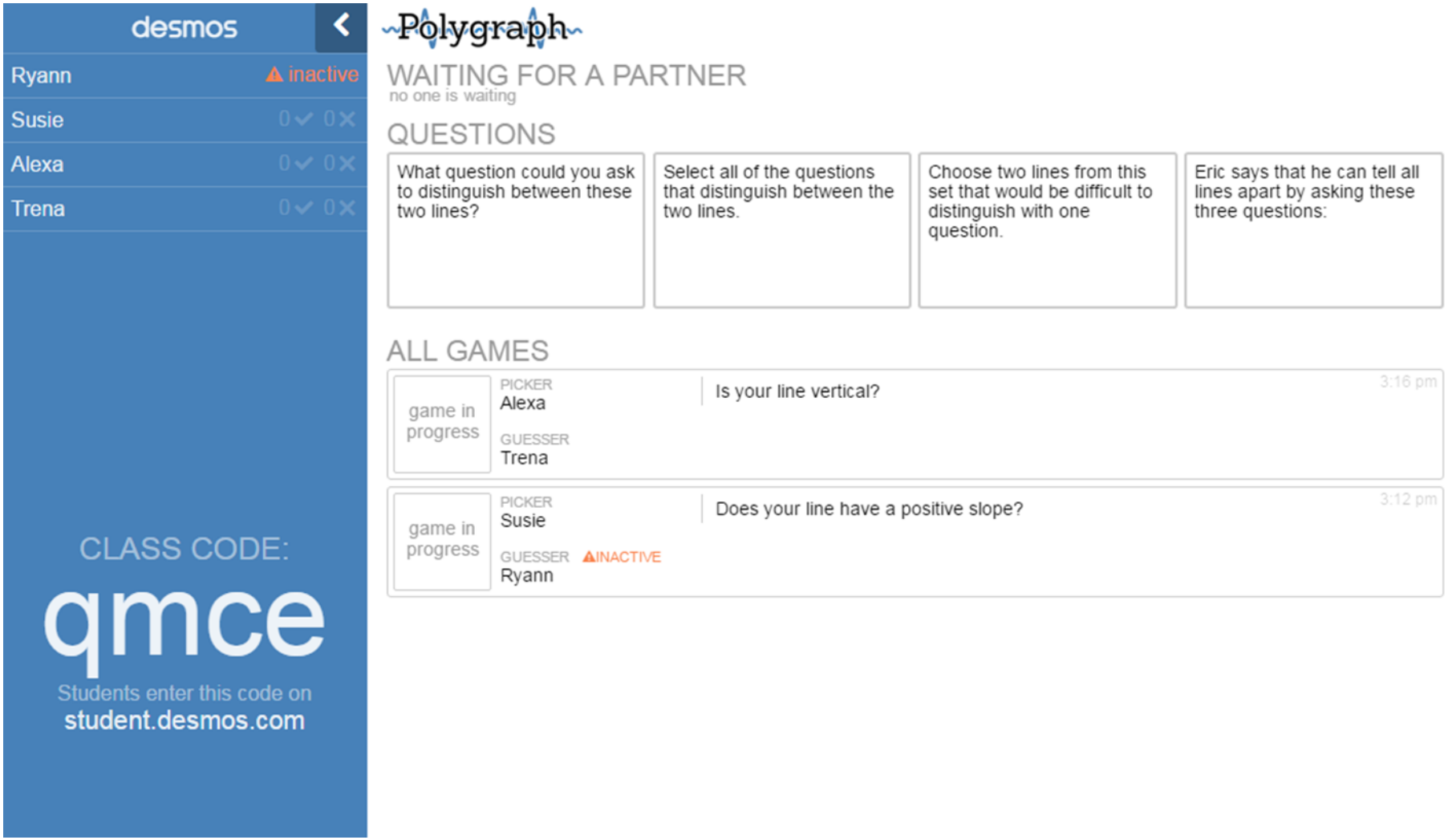
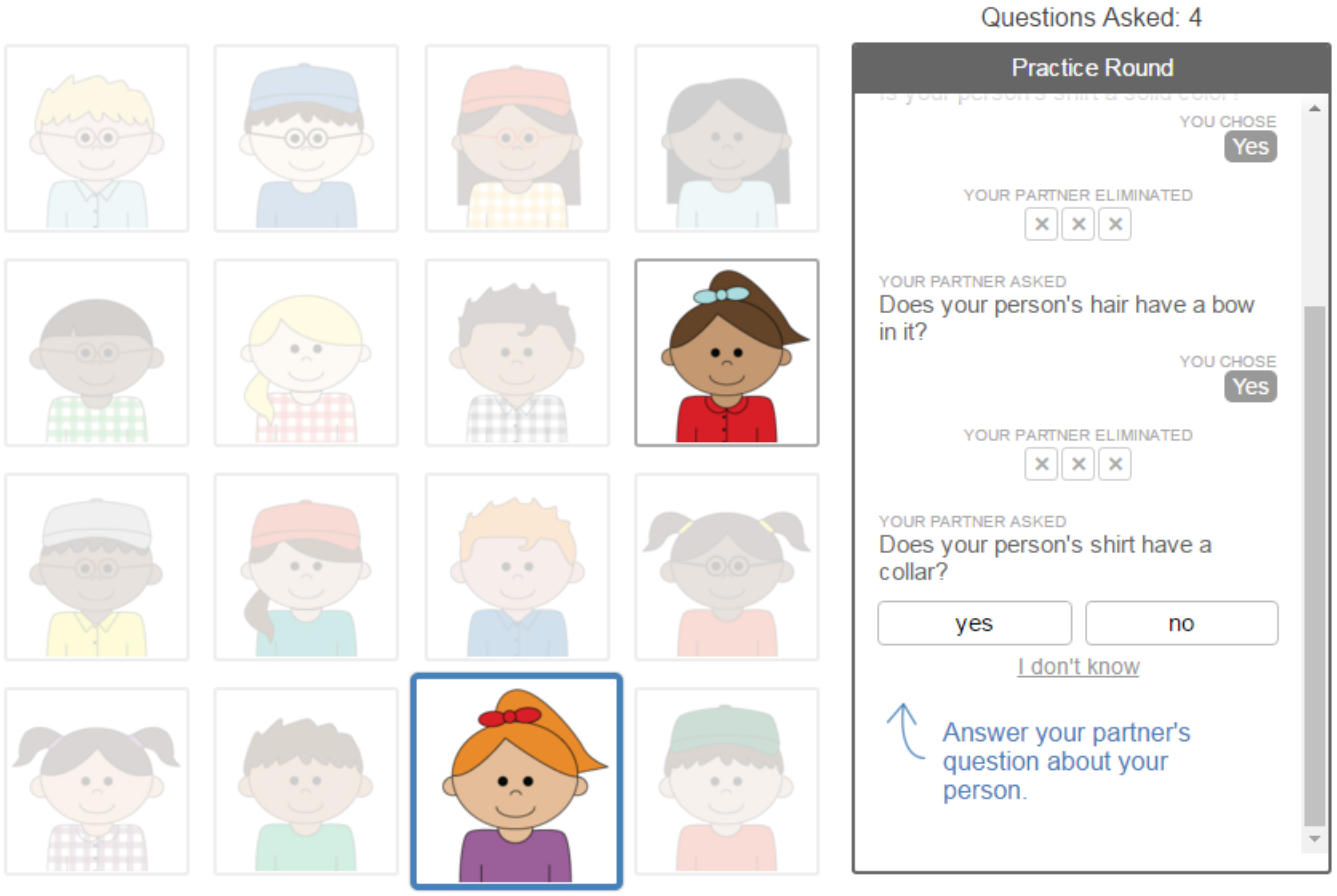
Technology Tool 2: DESMOS Polygraph



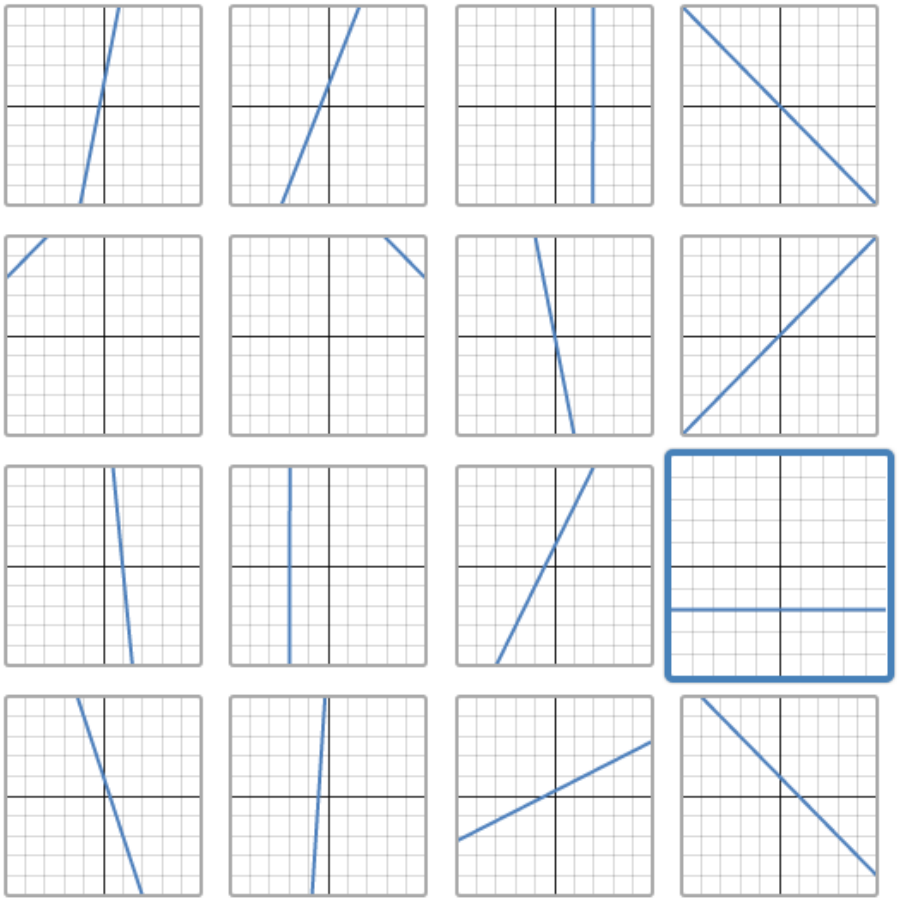
Technology Tool 2: DESMOS Polygraph

student.desmos.com

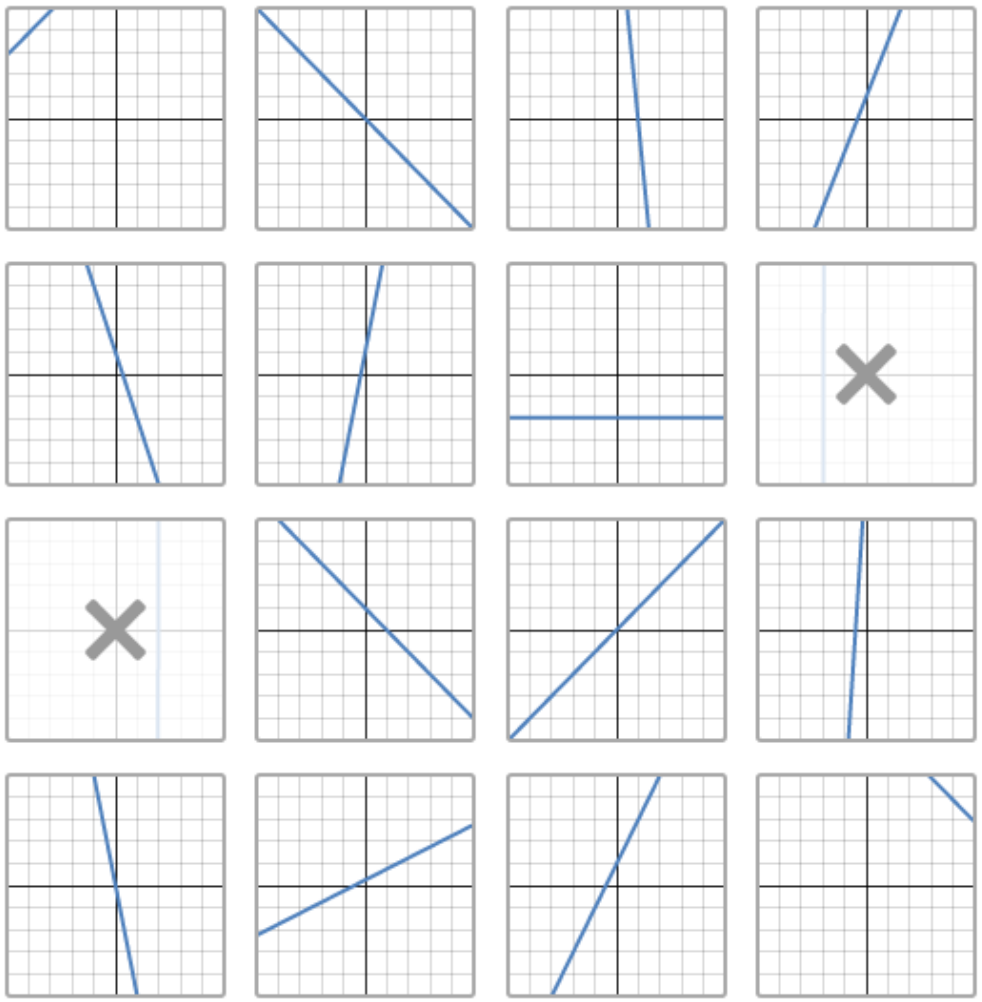


Technology Tool 2: DESMOS Polygraph

Select a line that's special to you for any reason. Next



Technology Tool 2: DESMOS Polygraph



Questions Asked: 1

Your Partner: Alexa

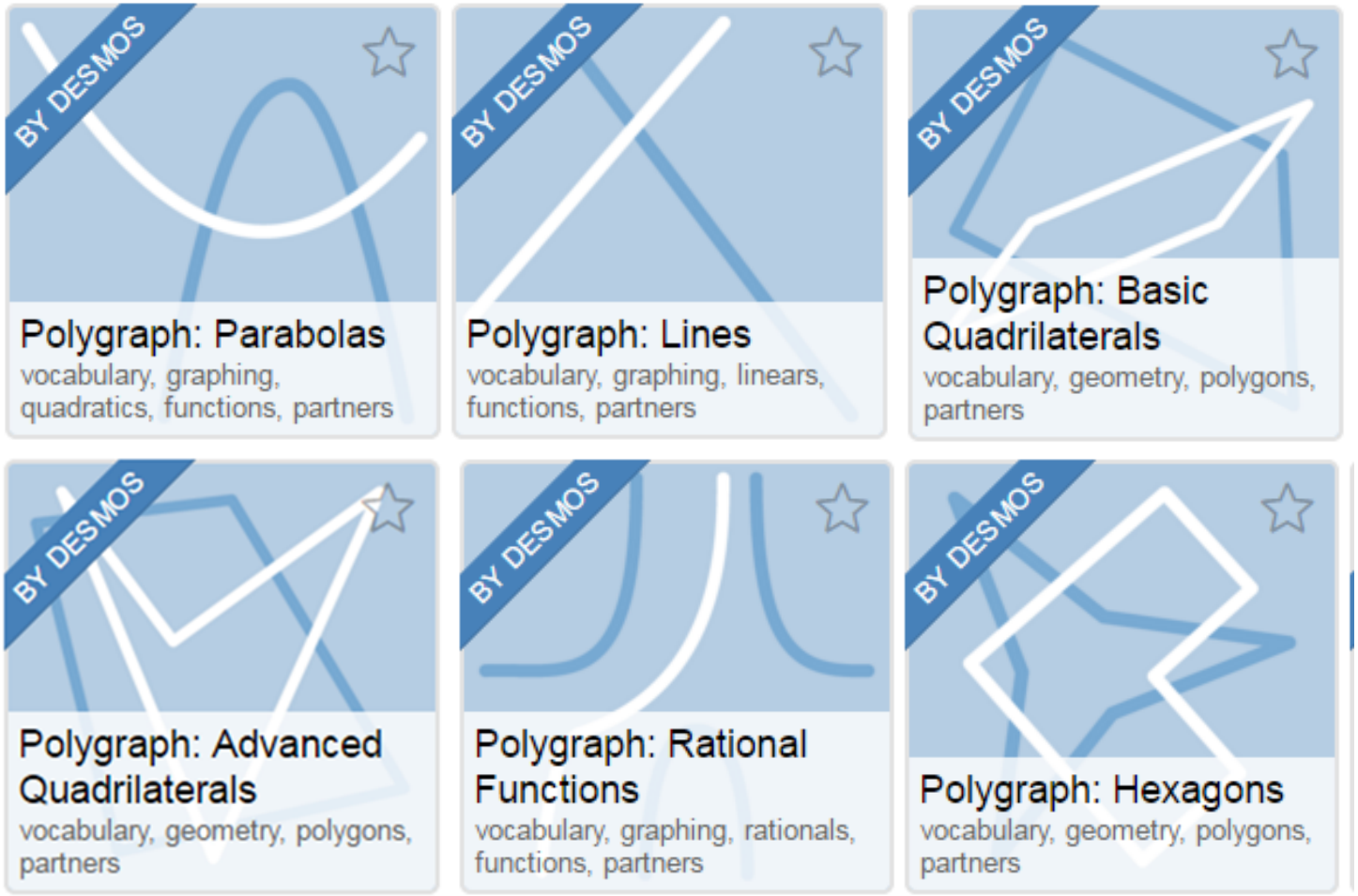
YOU ASKED
Is your line vertical?

ALEXA CHOSE
No

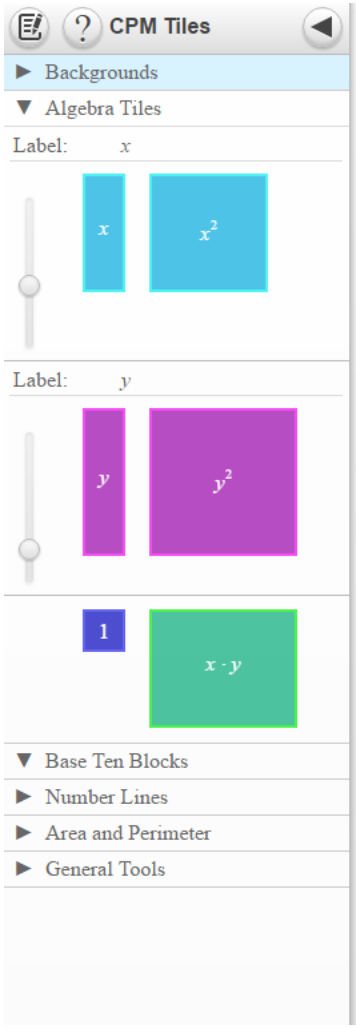
Select lines to eliminate based on Alexa's answer. Then press the button below.

Eliminate Selected

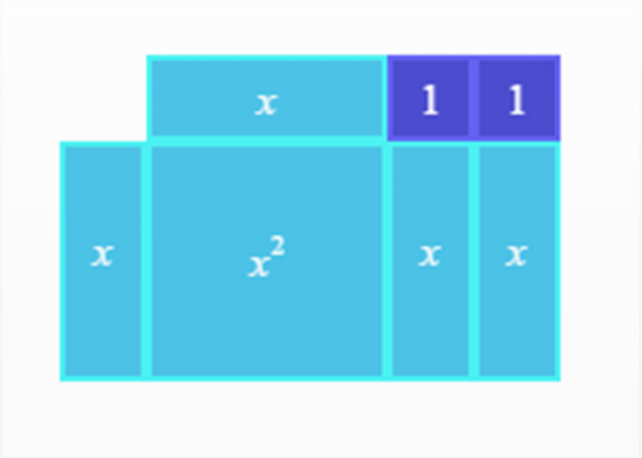
Technology Tool 2: DESMOS Polygraph



Technology Tool 3: Virtual Algebra Tiles



http://technology.cpm.org/general/tiles/



Technology Tool 4: TI Nspire

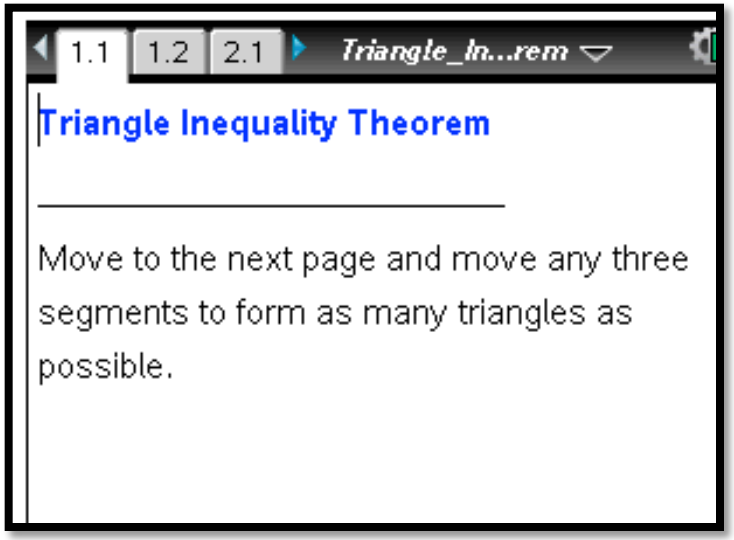
Nspire Activities:
www.education.ti.com/en/timathnspired/us/home

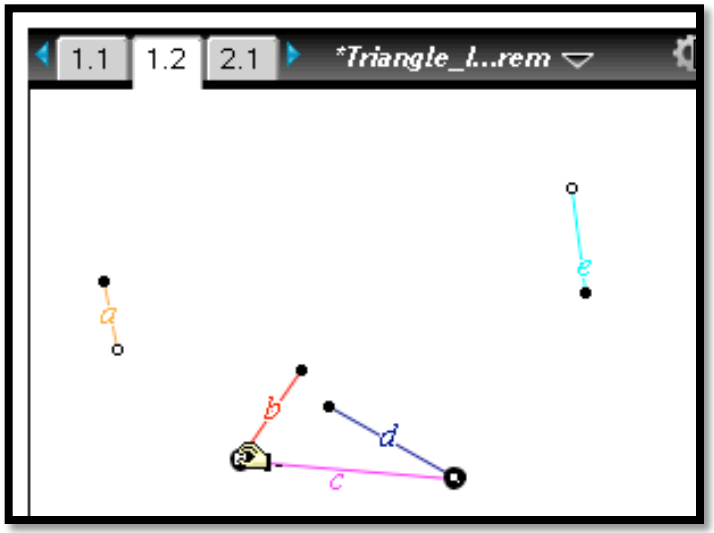
Tips to help promote algebraic thinking

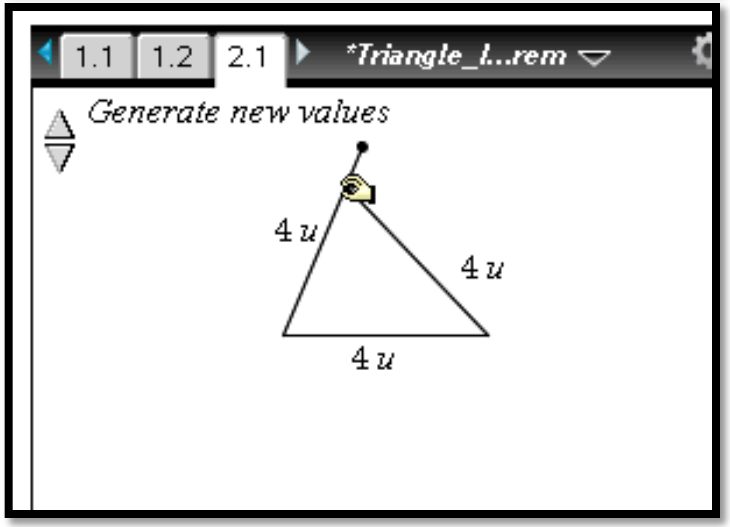
- Be knowledgeable about how to use the calculator and the activity you're using (do it yourself) ☺
- Finding a good activity will take time
- Ask yourself: Is the Nspire necessary? Will another calculator or resource work as well or better?
- Make your own activity on the Nspire!

Technology Tool 4: TI Nspire

Triangle Inequality Theorem Activity







Big Ideas:

•Variables, Quantitative Reasoning

Connections to Math Representations:

•Visual

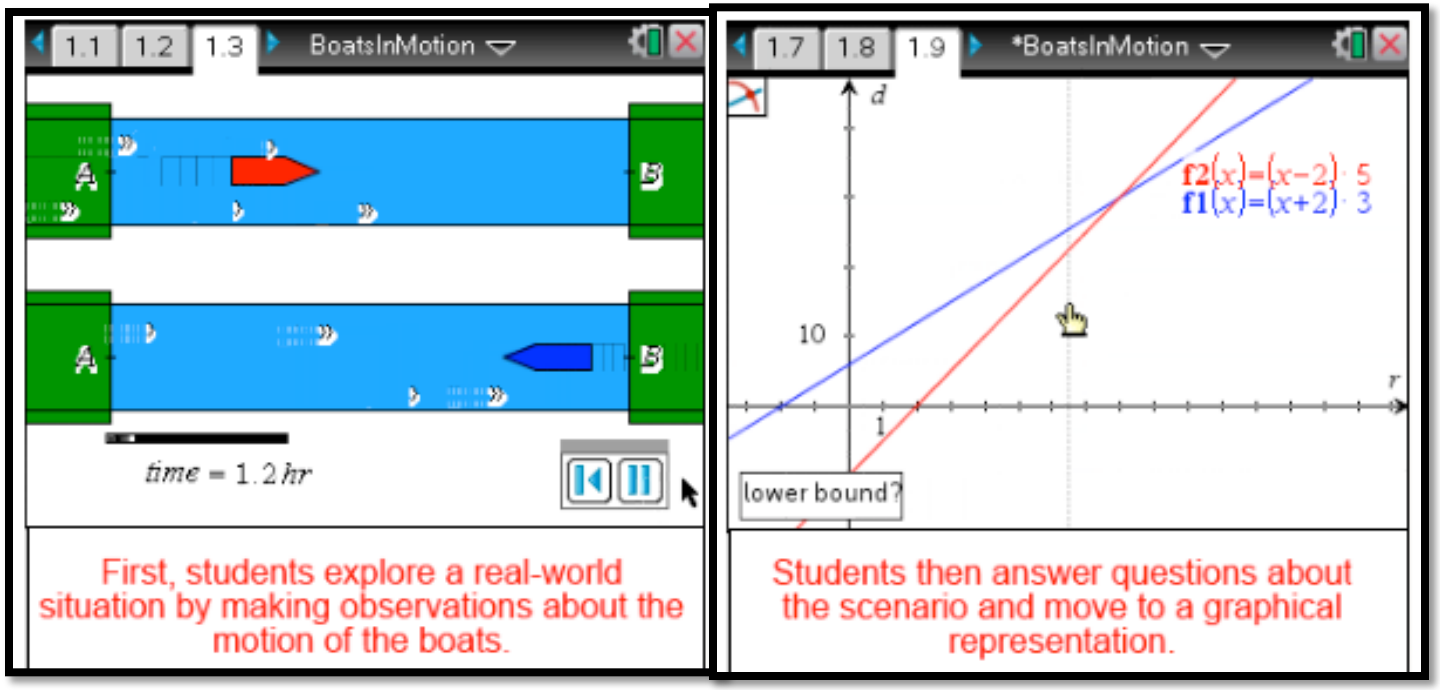
Technology Position Statement:

"Technology must be used…to support **all** students' learning of mathematical concepts and procedures."

https://education.ti.com/en/timathnspired/us/detail?id=3B617FB8D153437AB571DA497FB7C97D&sa=71A40A9FD9E84937B8C6A8A4B4195B58&t=A4B38973A30249BC8B300B7F6505F46E

Technology Tool 4: TI Nspire

Boats in Motion Activity



Big Ideas:

•Equations, Variables, Quantitative Reasoning, Functional Thinking

Connections to Math Representations:

•Visual, Contextual

"Effective teachers optimize the potential of technology to **develop** students' understanding, **stimulate** their interest, and **increase** their proficiency in mathematics."

https://education.ti.com/en/timathnspired/us/detail?id=6BC31F27694F44C2B92302917F531253&sa=2D7AB06424004125A392EB9A075CABC0&t=5C1EA70802CC424088668908D7BF89CE

Technology Tool 5: NCTM Illuminations

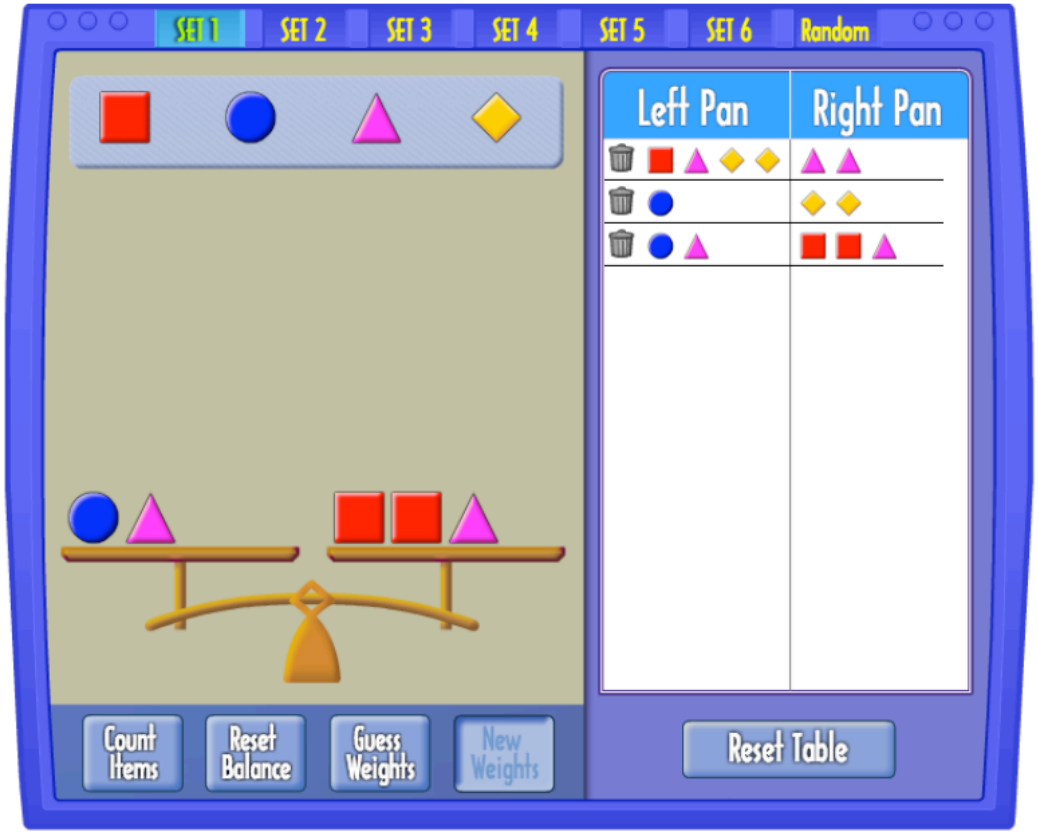
http://illuminations.nctm.org/

Examples

- Line of Best Fit
  - http://illuminations.nctm.org/Activity.aspx?id=4186
- Factorize
  - http://illuminations.nctm.org/Activity.aspx?id=3511
- Pan Balance-Shapes
  - http://illuminations.nctm.org/activity.aspx?id=3531

Technology Tool 5: NCTM Illuminations

Pan Balance-Shapes Activity



http://illuminations.nctm.org/Activity.aspx?id=3530

Big Ideas:

•Arithmetic, variables, quantitative reasoning

Connections to Math Representations:

•Visual, Symbolic

Technology Position Statement:

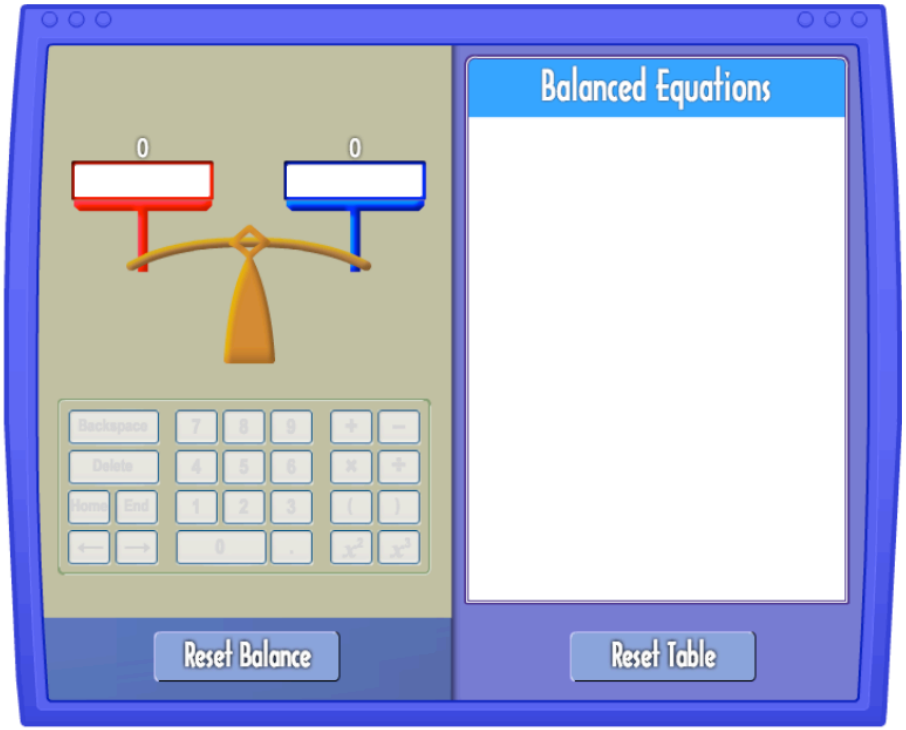
"Strategic use of technology in the teaching and learning of mathematics is the use of digital and physical tools by students and teachers in **thoughtfully designed ways**…"

http://illuminations.nctm.org/activity.aspx?id=3531

Technology Tool 5: NCTM Illuminations

Extensions

Pan Balance-Numbers



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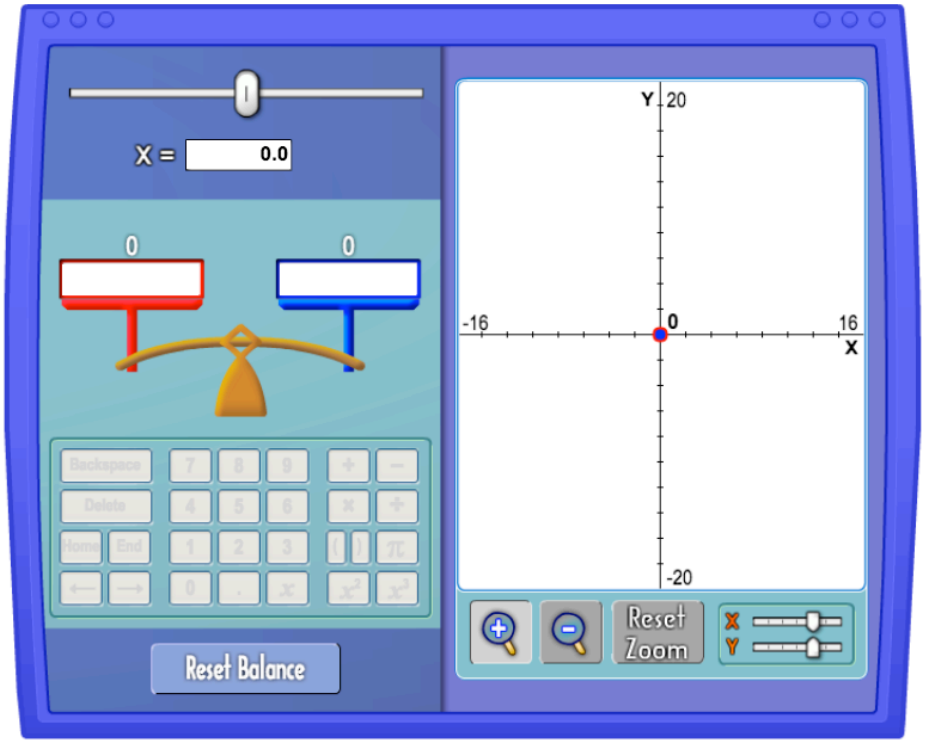
Pan Balance-Equations



http://illuminations.nctm.org/Activity.aspx?id=3529

Video Games, iPad Apps & More!

- *Target Zombies with Plants and Zombies*, MTMS, March 2013, 18(7), Kurz, Quick Reads
- Angry Birds Mathematics: Parabolas & Vectors, MT, December 2013, 107(5). Lamb
- Geogebra, Sketch Explorer, Geo Designer, Quick Graph, Cabri, PocketCAS, GraphiCal FreeGraCAlc, Educreations, and more!
- iSolveIt: MathScaled (Balance scales)
  - Exploring Algebriac Misconceptions Using Technology Sakow & Karaman, November 2015, 21(4)
  - http://isolveit.cast.org/p/scaled/

And even More!

- *Apps for teaching, not just reviewing*
  - MTMS, Wall, Beatty, & Rogers, March 2015 21(7)
  - http://www.nctm.org/Publications/teaching-children-mathematics/2015/Vol21/Issue7/Apps-for-teaching,-not-just-reviewing/
- Math-Twitter-Blog-o-Sphere (MTBoS)
- Socrative.com
  - MTMS January 2016 Post, Yenca
  - http://www.nctm.org/Publications/Mathematics-Teaching-in-Middle-School/Blog/Formative-Feedback_-The-Way-Digital-Tools-Are-Used-Can-Make-the-Difference/
- What is your favorite APP for addressing algebraic thinking?

Essential Element

An excellent mathematics program integrates the use of mathematical tools and technology as essential resources to help students learn and make sense of mathematical ideas, reason mathematically, and communicate their mathematical thinking.

(NCTM, PtA, 2014, p. 78)

NCTM Publications

www.nctm.org

- *Blanton, M., Levi, L., Crites, T., & Dougherty, B. J. (2011). Developing Essential Understandings of Algebraic Thinking for Teaching Mathematics in Grades 3-5.*
- *Cooney, T. J., Beckmann, S., Lloyd, G. M. (2010). Developing Essential Understanding of Functions in Grades 9-12.*
- *Graham, K., Cuoco, A., Zimmermann, G. (2010). Focus in High School Mathematics: Reasoning and Sense Making in Algebra.*
- *Greenes, C. E., & Rubenstein, R. (Editors). (2008). Algebra and Algebraic Thinking in School Mathematics, 70th Yearbook.*
- *Lloyd, G., Herbel-Eisenmann, B., Star, J. R. (2011). Developing Essential Understanding of Expressions, Equations, and Functions in Grades 6-8.*
- *Principles to Action: Ensuring Mathematical Success for All*

National Council of Teachers of Mathematics
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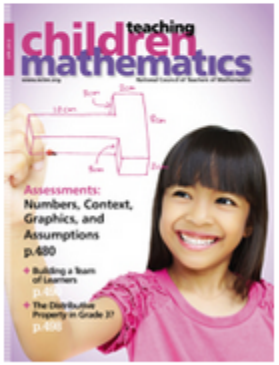
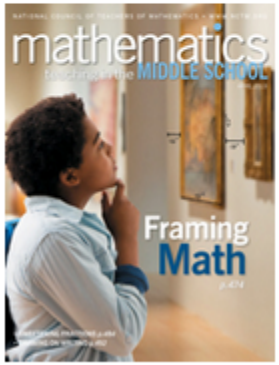
- *Mathematics Teaching in the Middle School* (5-9)
- *Mathematics Teacher* (8-14)





National Council of Teachers of Mathematics

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To involve more teachers, additional e-memberships can be added for just $10 each.

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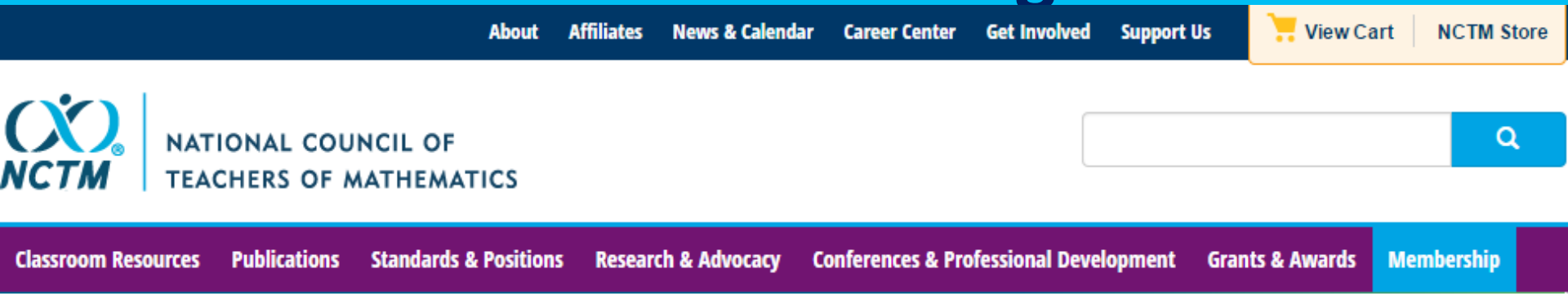

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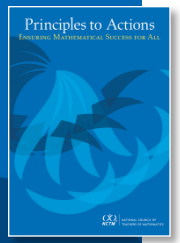

NCTM Interactive Institutes
www.nctm.org

***Engaging Students in Learning: Mathematical Practices,* Grades K-8**

July 11 – July 13, 2016, Atlanta, GA

***Engaging Students in Learning: Mathematical Practices and Process Standards,* High School**

July 14 – July 16, 2016, Atlanta, GA

Algebra Readiness Institute, Grades 6-8

July 18-20, 2016, Denver, CO

Number and Operations Institute, Grades Pk-5

July 21-23, 2016, Denver CO

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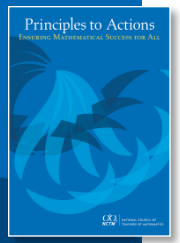

NCTM Regional Conferences
www.nctm.org

- Phoenix
  October 26–28, 2016

- Philadelphia, PA
  October 31–November 2, 2016

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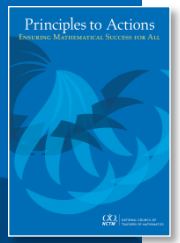

NCTM Innov8

November 16-18, 2016, St. Louis

"Engaging the Struggling Learner"

Community. Collaboration. Solutions.

Bring your team and engage in a hands-on, interactive, and new learning experience for mathematics education.

With a focus on "Engaging the Struggling Learner," become part of a team environment and navigate your experience through three different pathways:

- Response to Intervention (RtI)
- Supporting productive struggle
- Motivating the struggling learner

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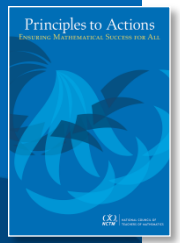

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2017 Annual Meeting and Exposition

April 5–8, 2017
San Antonio

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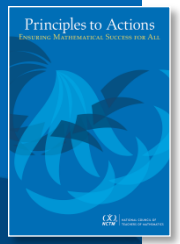
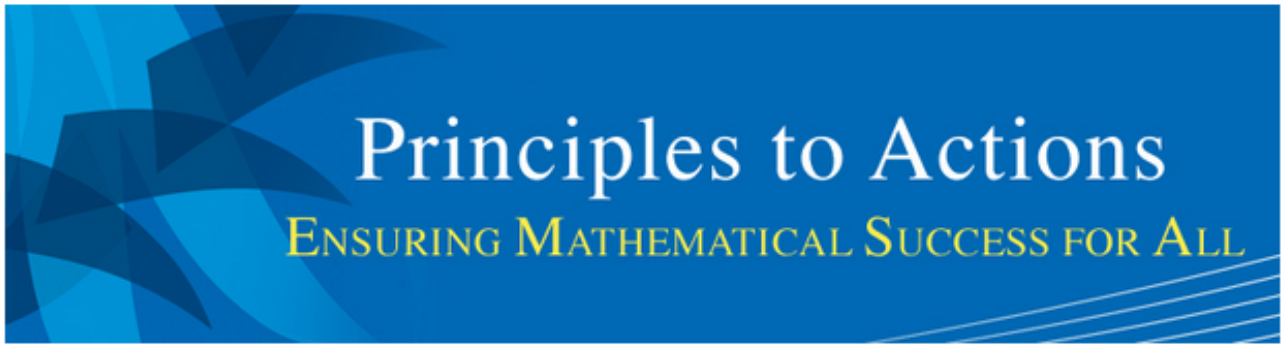


http://www.nctm.org/PtA/



Specific, research-based teaching practices that are essential for a high-quality mathematics education for all students are combined with core principles to build a successful mathematics program at all levels.

Principles to Actions offers guidance to teachers, mathematics coaches, administrators, parents, and policymakers.

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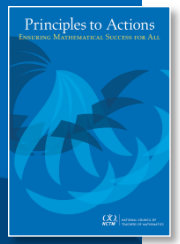

Principles to Actions Resources

- *Principles to Actions* Executive Summary (in English and Spanish)
- *Principles to Actions* overview presentation
- *Principles to Actions* professional development guide (Reflection Guide)
- Mathematics Teaching Practices presentations
  - Elementary case, multiplication (Mr. Harris)
  - Middle school case, proportional reasoning (Mr. Donnelly) (in English and Spanish)
  - High school case, exponential functions (Ms. Culver)
- *Principles to Actions* Spanish translation

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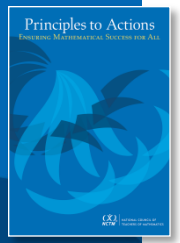

http://www.nctm.org/PtAToolkit/

Principles to Actions Professional Learning Toolkit

8

Grade-band specific professional learning modules focused on the

- Effective Teaching Practices, and
- Guiding Principles from *Principles to Actions: Ensuring Mathematical Success for All*.

Presentation, presenter notes, and required materials are provided in each module to support professional learning with teachers through analyzing artifacts of teaching (e.g., mathematical tasks, narrative and video cases, student work samples, vignettes) and abstracting from the specific examples general ideas about how to effectively support student learning.

The Teaching and Learning Modules were developed in collaboration with the Institute for Learning (IFL) at the University of Pittsburgh.

Effective Teaching Practices

The Case of Amanda Smith and the Donuts Task

Connecting Representations & Pose Purposeful Questions – Elementary

During this session you will solve and discuss the donuts task and then watch video clips of a class working on the task. After viewing the video you will relate the teacher and student actions to the effective mathematics teaching practices and consider how you might apply specific mathematics teaching practices to your work.

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Thank you!

Contact Information

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