The *Design & Findings* of a *Random-Controlled Trial* of a **Game-Based** *Successful Mathematics Intervention*






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Institute for Equity in Math and Science Education (IEMSE)

Today, we'll:

1. Briefly **share findings**
2. Review the **research-design process** (interactive workshop)
   a) Needs analysis including pre-design research
   b) Establish learning goals
   c) Game design
   d) Pilot studies and instrument validation
3. **Group Discussion**

Beginning with the Final Study

- **Research Design**

  Experimental study measuring the effect of **four educational games** and related inquiry- based activities on students' understandings of ratios, coordinate plane, and number systems (fractions and decimals)

- 48 classrooms randomly assigned to Group A or Group B
- All classrooms were fifth grade in one district (75% Hispanic, 24% White)
- Math Gains measured on Mathematics Learning II (reliability .89)
- Observations of classrooms (twice per teacher by 2 observers)

Theoretical Framework- Math Snacks

- Theoretical Framework - constructivist learning principles for building knowledge (Scardamlia & Bereiter, 2008 ; *problem-based* approach has been described as *anchored instruction* (Alessi & Trollip, 2001; Moreno, 2010; Affordances of games for concept images and learning (Tall and Vinner; J. Gee, Keith Devlin);Additional activities to apply knowledge learned from games. Use of useful common core. Research on pivot points (Stanford).

Math Snacks Intervention Model

Each lesson protocol included:

- game play session with group discussion (30-40 minutes),
- hands-on activity related to game play (30-40 minutes),
- second game-play session with a final discussion (30-40 minutes)
- optional out-of-school game play – 93% of students engaged in game play out of school

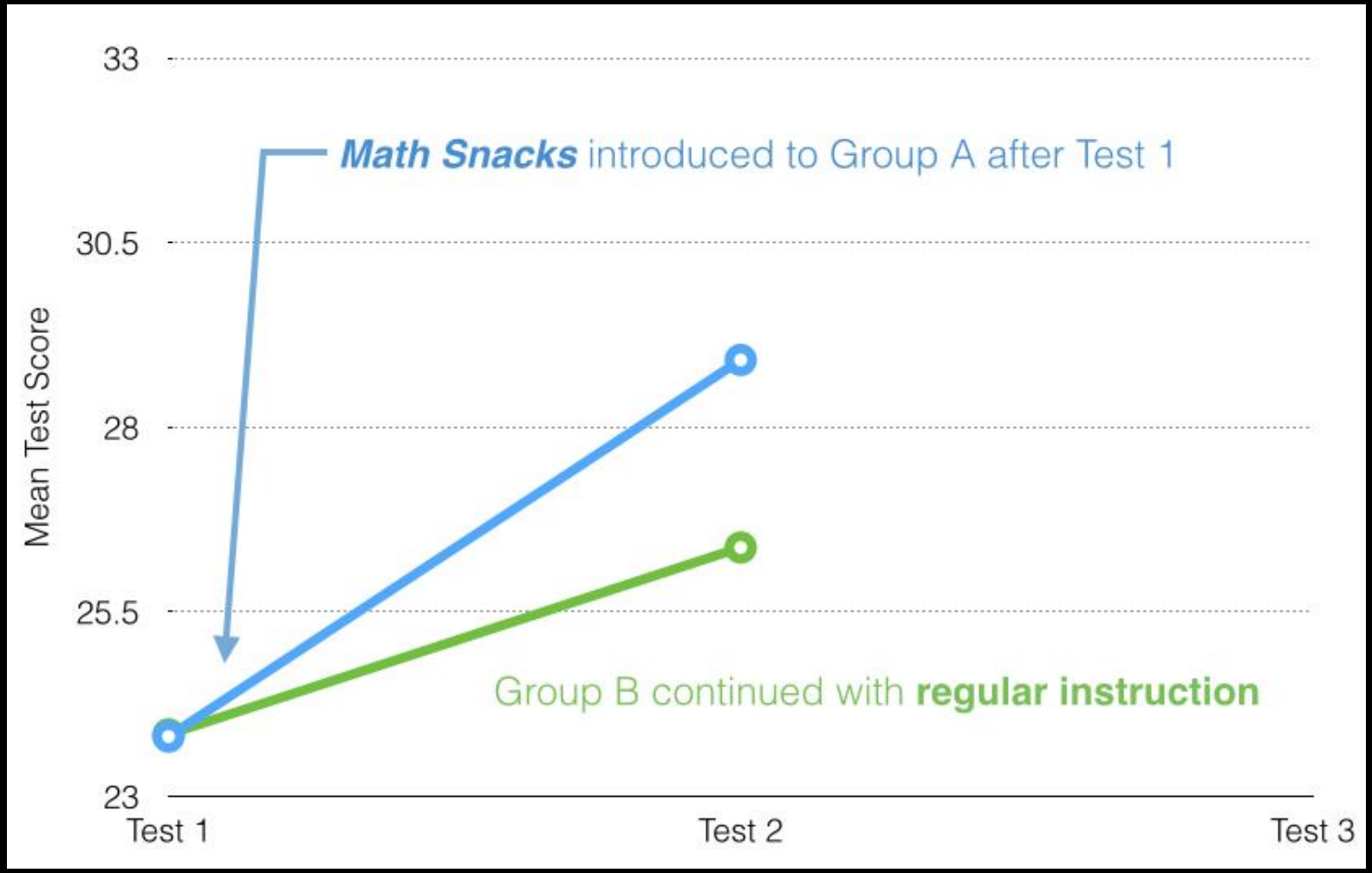
Observations of classroom teaching and game playing (2 times per teacher, trained observers)

Research Questions

- 1. Will students who were taught using the *Math Snacks Intervention (A)* show **greater growth in mathematical knowledge** (ratios, coordinate plane, and fractions, decimals) than students taught mathematics using only the reg. district curriculum (B)?
- 2. Will students who received the delayed five-week intervention (B) have **equivalent math knowledge gains** as students (A)who received the first five-week intervention?
- 3. Were initial gains by Group A sustained?

Scores on *Measure of Mathematics Learning II*

(Group A n=361, Group B n=380



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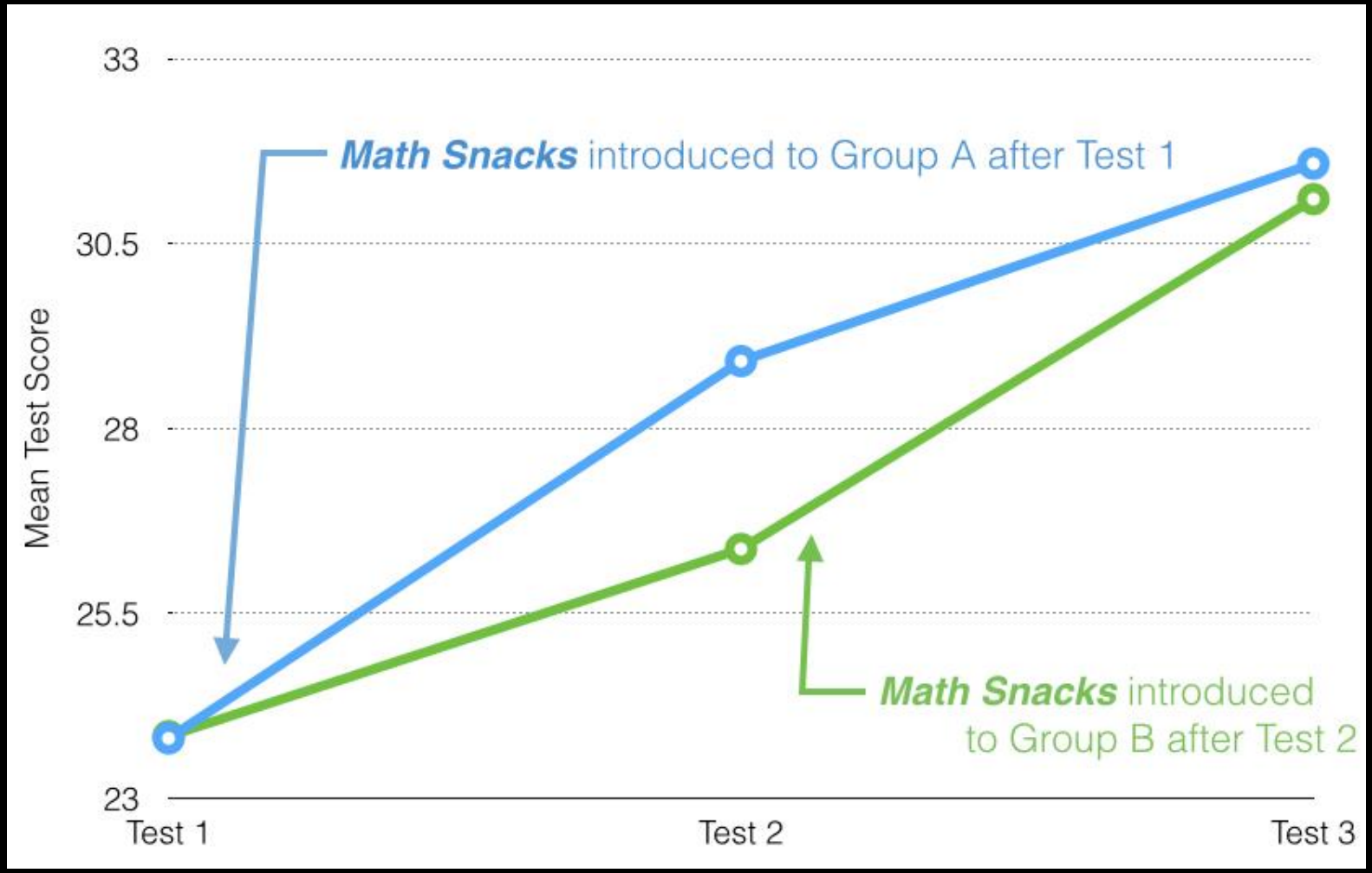

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Timeline for Delayed Treatment Model

	Test 1	5 week period	Test 2	5-week period	Test 3
Group **A**	√	***Math Snacks*** with district math curriculum	√	District math curriculum	√
Group **B**	√	District math curriculum	√	***Math Snacks*** with district math curriculum	√

Mean Scores on *Measure of Mathematics Learning II*

	Test 1		Test 2		Test 3
Group **A** *n = 361*	23.64 (8.47)	*Significant gain* $p < .001$	28.91 (8.77)	-	31.58 (8.80)
Group **B** *n = 380*	23.84 (8.36)		26.37 (8.71)	*Significant gain* $p < .001$ -	31.10 (8.43)

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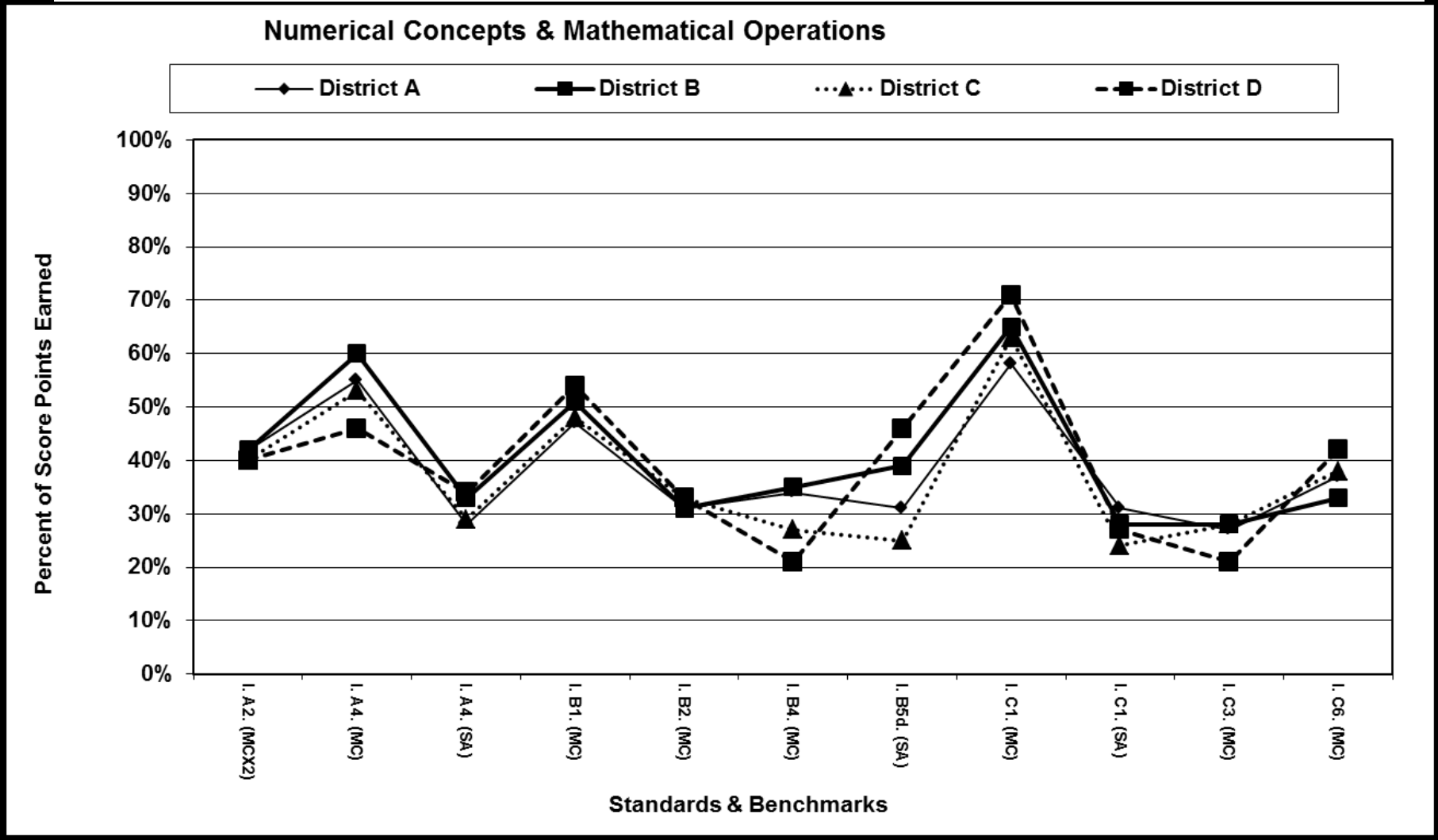
Pre-Math Snacks Research

- **Pre-design Research-** Using 24,000 standardized tests with open-ended items, 500 hours of classroom observation, and additional documentation of areas teachers find mathematically challenging lead to the mathematical goals for Math Snacks.

Karin Wiburg and Ken Korn (2008 and 2011)

Same Troubles Year after Year (Wiburg & Korn)



Common low scores: B4- Proportional Thinking, B5- Operations with fractions and decimals, C1- estimation, C4- Interpret and Use Ratios 2008 data

Suite of Tools

Learner Guides for animations

Teacher Guides

5 games

3 apps

6 animations

Teaching With Videos

Start with Needs

Define Outcomes

- What does it look like if user understands?
- How is it currently taught?
  - What works?
  - What doesn't?

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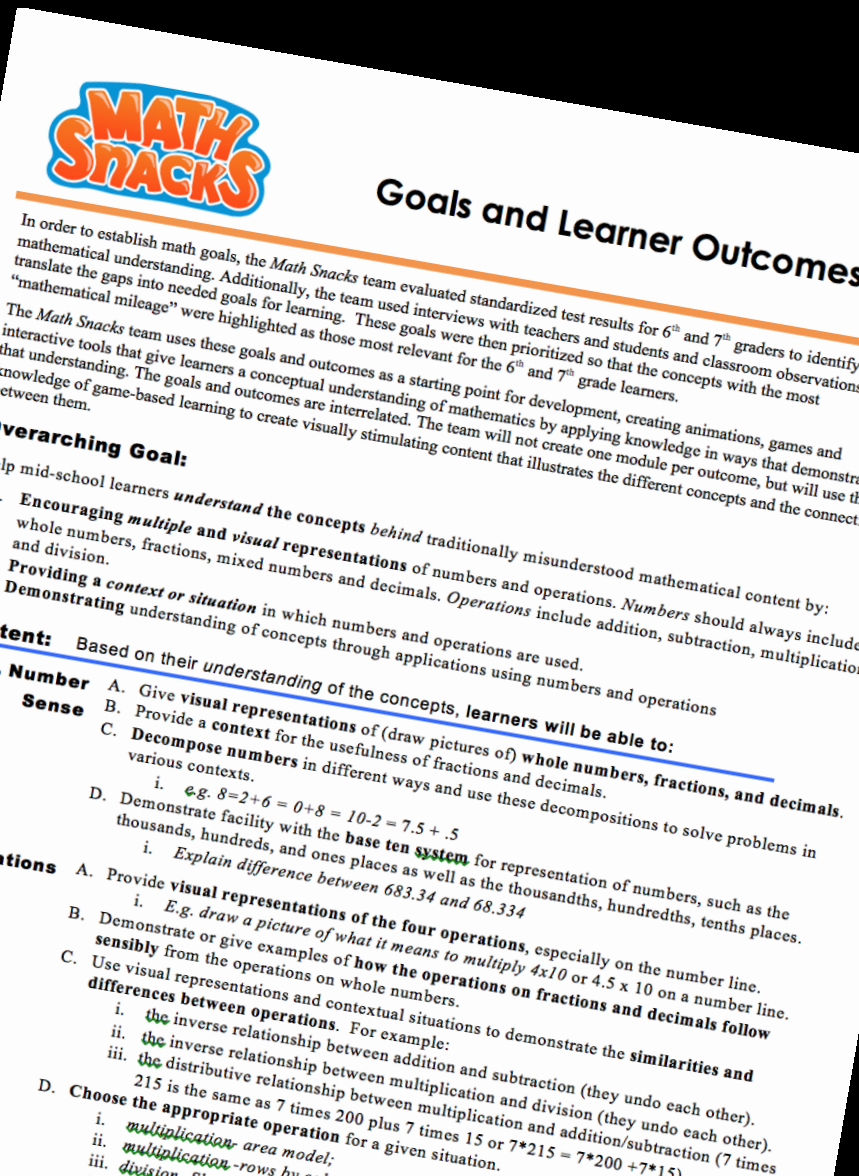


MATH SNACKS

Goals and Learner Outcomes

In order to establish math goals, the *Math Snacks* team evaluated standardized test results for 6th and 7th graders to identify mathematical understanding. Additionally, the team used interviews with teachers and students and classroom observations to translate the gaps into needed goals for learning. These goals were then prioritized so that the concepts with the most "mathematical mileage" were highlighted as those most relevant for the 6th and 7th grade learners.

The *Math Snacks* team uses these goals and outcomes as a starting point for development, creating animations, games and interactive tools that give learners a conceptual understanding of mathematics by applying knowledge in ways that demonstra that understanding. The goals and outcomes are interrelated. The team will not create one module per outcome, but will use th knowledge of game-based learning to create visually stimulating content that illustrates the different concepts and the connect between them.

Overarching Goal:

Help mid-school learners ***understand*** **the concepts** *behind* traditionally misunderstood mathematical content by:

1. **Encouraging *multiple* and *visual* representations** of numbers and operations. *Numbers* should always include whole numbers, fractions, mixed numbers and decimals. *Operations* include addition, subtraction, multiplication and division.
2. **Providing a *context or situation*** in which numbers and operations are used.
3. **Demonstrating** understanding of concepts through applications using numbers and operations

Content: Based on their *understanding* of the concepts, **learners will be able to:**

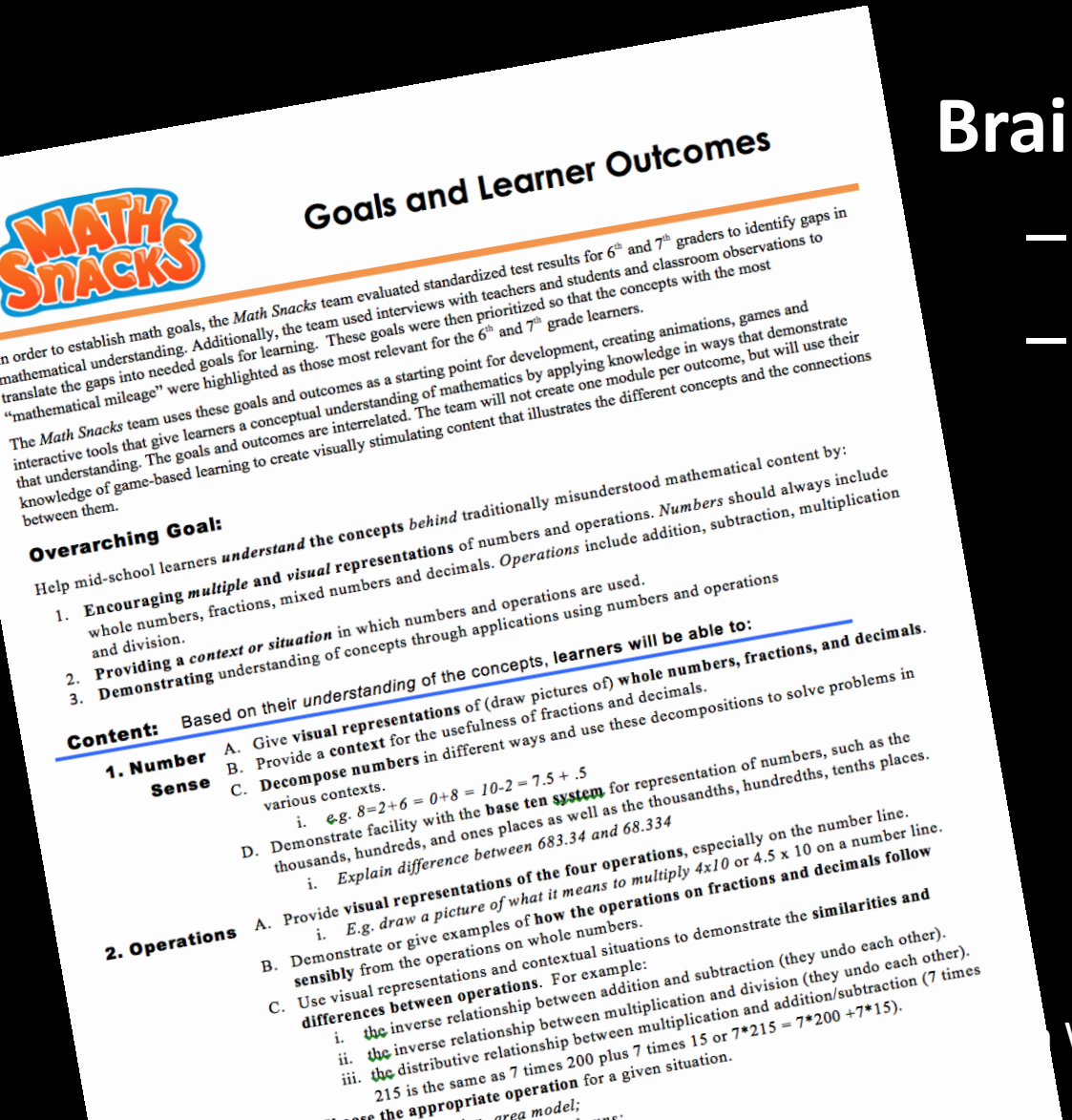
1. Number Sense

A. Give **visual representations** of (draw pictures of) **whole numbers, fractions, and decimals**.
B. Provide a **context** for the usefulness of fractions and decimals.
C. **Decompose numbers** in different ways and use these decompositions to solve problems in various contexts.
   i. *e.g. 8=2+6 = 0+8 = 10-2 = 7.5 + .5*
D. Demonstrate facility with the **base ten system** for representation of numbers, such as the thousands, hundreds, and ones places as well as the thousandths, hundredths, tenths places.
   i. *Explain difference between 683.34 and 68.334*

2. Operations

A. Provide **visual representations of the four operations**, especially on the number line.
   i. *E.g. draw a picture of what it means to multiply 4x10* or 4.5 x 10 on a number line.
B. Demonstrate or give examples of **how the operations on fractions and decimals follow sensibly** from the operations on whole numbers.
C. Use visual representations and contextual situations to demonstrate the **similarities and differences between operations**. For example:
   i. the inverse relationship between addition and subtraction (they undo each other).
   ii. the inverse relationship between multiplication and division (they undo each other).
   iii. the distributive relationship between multiplication and addition/subtraction (7 times 215 is the same as 7 times 200 plus 7 times 15 or 7*215 = 7*200 +7*15)
D. **Choose the appropriate operation** for a given situation.
   i. *multiplication- area model;*
   ii. *multiplication -rows by*
   iii. *division*

Make a Tool



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area model;

Brainstorm

- Animation? Game?
- What does the learner do?
  - Inquire?
  - Memorize?
  - Explore?
  - Experiment?

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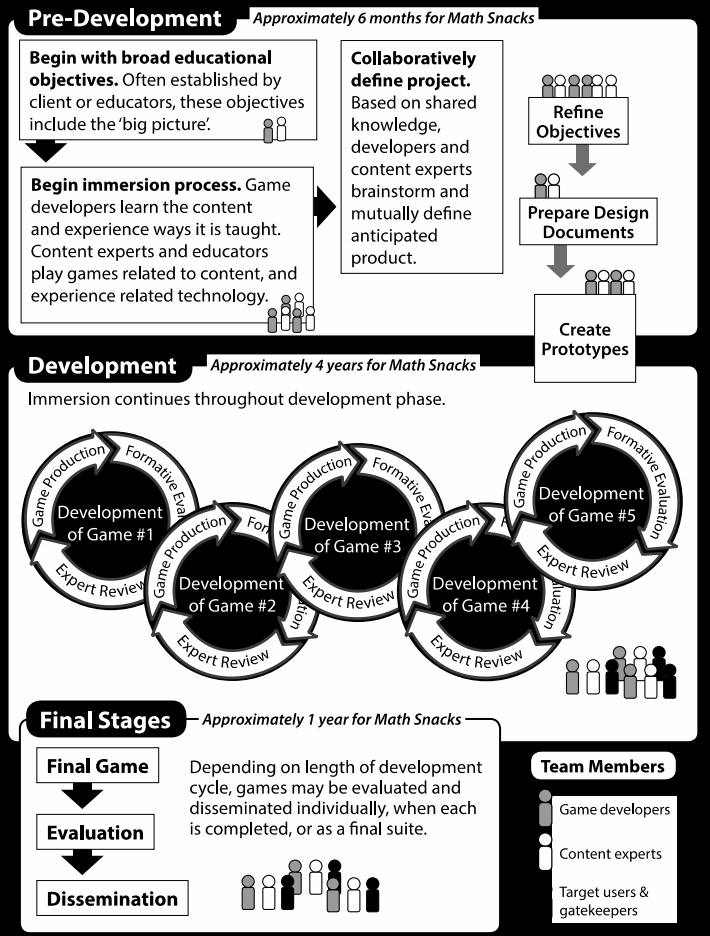
Learning Games Design Model

(this is a whole process)



Chamberlin, B. A., Trespalacios, J., Gallagher, R. (2014). Bridging Research and Game Development: **A Learning Games Design Model for Multi-Game Projects**. In Mehdi Khosrow-Pour (Ed.), ***Educational Technology Use and Design for Improved Learning Opportunities*** (pp. 151–171). Hershey, PA: IGI Global.

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Assessment Measures

- *Measure of Mathematics Learning II*
  Released Items from the NAEP modified after trials
- OLE2- *Observation of Learning Environments*
- Self-efficacy
- Embedded gameplay data especially for out-of-school learning

Small group activities

- Possibilities for pilot testing of new game or animation.
- What kind of instruments are needed to gather the data you want?

What have *you* learned?

- What are you measuring? (not just content)
- Encouraging inquiry-based learning

Large Pilot testing Spring 2013

Keys to Success:

- Pilot testing of product and tools
  - With learners, teachers, in classrooms
- Extensive review of teacher use
- Observers in classroom
- Multiple type of assessment (quantitative, qualitative, embedded)

Limitations:

- While everyone gained, too much disparity and there was no pre-treatment equivalence
- Disparity in teaching quality

Final questions and discussion.

- Write questions and answers from the group on any aspect of the design as well as final testing.
- Pre-design research?
- Foundational design?
- Pilot studies?
- Random Control Trial Study?

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