Game Development and Design: Blood, Sweat, and Tears

Greg Chung

Warp Speed, Mr. Sulu: Integrating Games, Technology, and Assessment to Accelerate Learning in the 21st Century

Redondo Beach, CA – April 29-30, 2014

Structure of Talk

- Blood: Large-scale randomized controlled trial (RCT)
- Sweat: How did we get there?
- Tears: Innovations and impact

Project Goal

- Develop and evaluate video games aimed at improving students' knowledge and skills in pre-algebra topics
  - ✓ *Focus on rational numbers, solving equations, functions (middle school)*
  - ✓ *Develop and test games*
  - ✓ ***RCT: Examine effects of game on learning of fraction concepts***

The Blood:
Randomized Controlled Trial

Research Question

- Does playing CATS-developed rational number games result in more learning of rational number concepts compared to playing a comparison set of games?

Sample

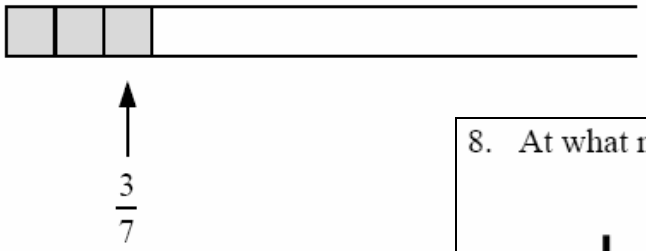
- 62 classrooms randomly assigned to condition
  - ✓ *30 treatment classrooms*
  - ✓ *29 control classrooms*
  - ✓ *3 classes dropped because of schools' technology*
  - ✓ *~1700 students*
- Final sample—59 classrooms, 9 districts, 24 schools, CA and NV, ethnically diverse

Procedure

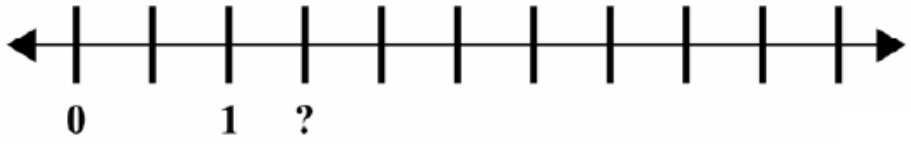
- Teachers integrated math games into their curriculum
  - ✓ *Rational number or control topic*
  - ✓ *3 hours professional development*
  - ✓ *Implementation window: Jan to April 2012 (pre-state testing)*
    - ❖ *Pretest (30min)*
    - ❖ *10 gameplay days within window (40min per occasion)*
    - ❖ *Delayed posttest 1 week after last game (30min)*
- $600 honorarium to teacher

Measures

3. The figure below shows $\frac{3}{7}$ of a whole unit shaded. Complete the figure to show where the whole unit ends. Be sure to draw lines ("|") to show where each piece is.



8. At what number is the "?" located?



13. $\frac{1}{6} + \frac{1}{4} = \frac{\square}{\square}$

a. Complete the equation for the table to help you find the value of y when the value of x is 180, by filling in the **values of the change in** y and **change in** x and the **value of** x.

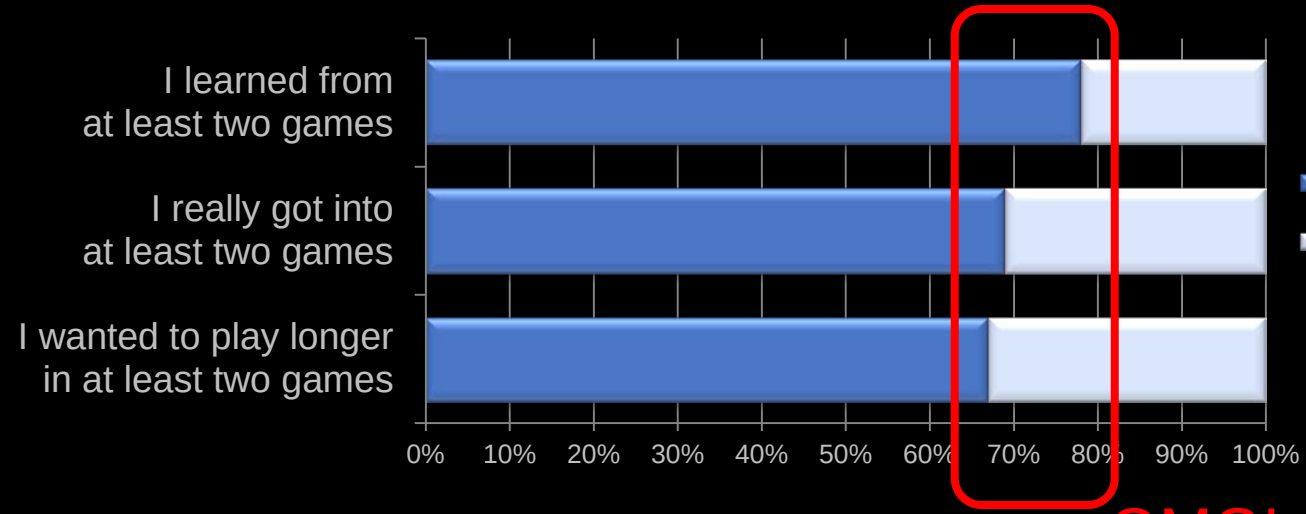
$$y = \left(\frac{\square}{\square}\right)\left(\square\right)$$

18. $\frac{8}{9} \times \frac{\square}{\square} = 1$

Results

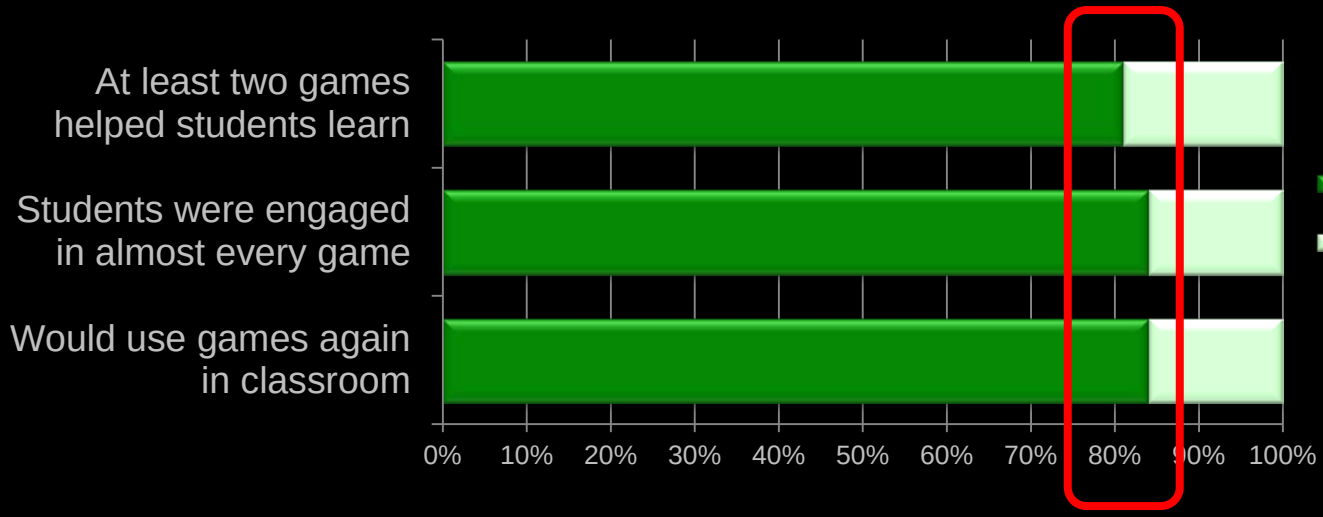
- The treatment condition performed significantly higher on the posttest than the comparison condition
  - ✓ *Treatment condition (n = 30) played 4 games related to fractions*
  - ✓ *Comparison condition (n = 29) played 4 alternative games (solving equations)*
  - ✓ *No differences between conditions on pretest*

Student's Perceptions



OMG!

Teacher's Perceptions



OMG!!

Efficacy Trial Results

- Multi-level model shows significant effects of treatment, effect size = .6 (Li Cai discussing next session)

OMG!!!

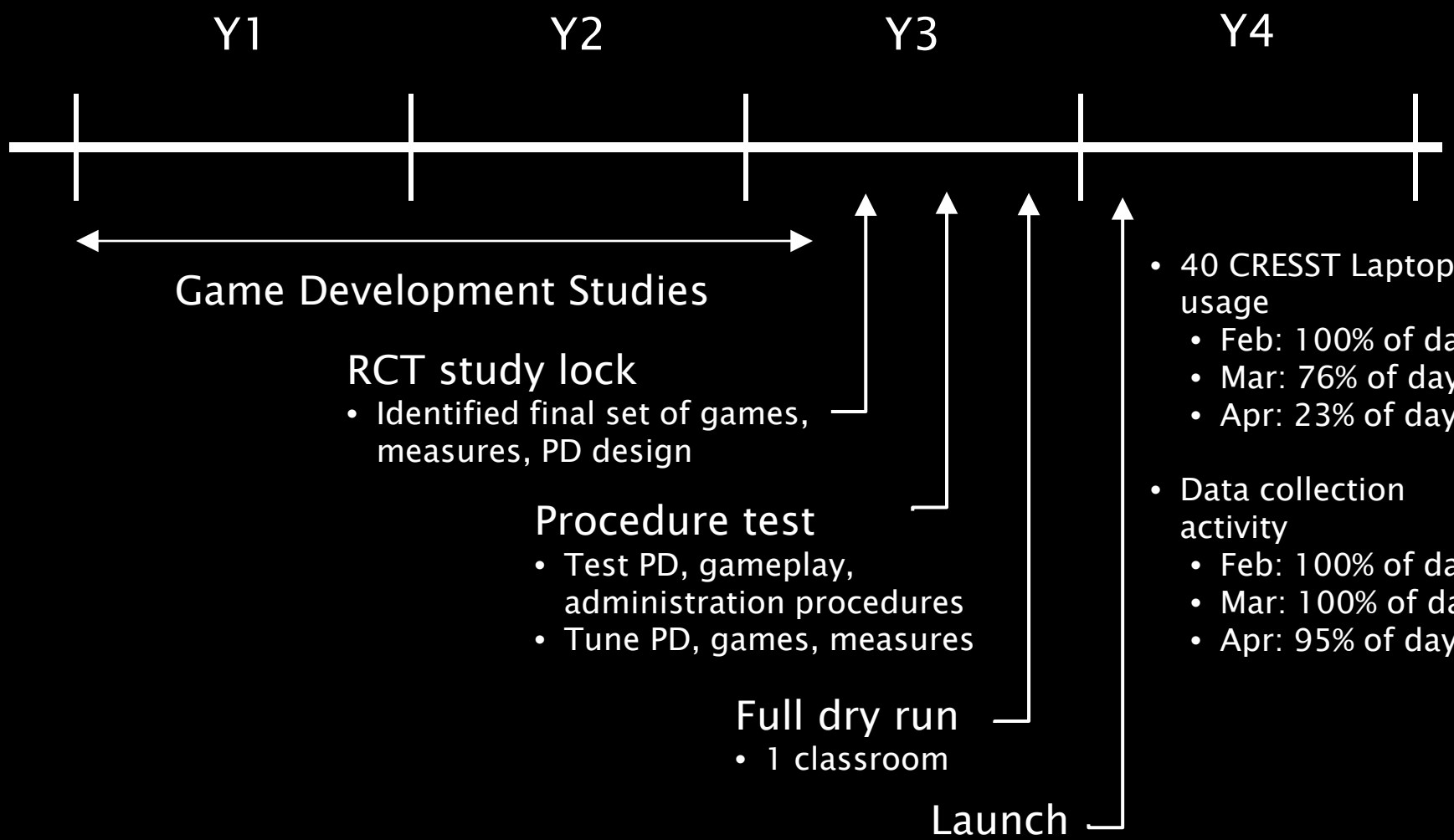
Type of Intervention	Mean Effect Size
Instructional format	.21[a]
Instructional component/skill training	.36[a]
Focused on individual students	.40[a]
Simulation and games	.34[b]
Computer-assisted instruction	.31[b]

[a]Lipsey, M. W. et al. . (2012). *Translating the Statistical Representation of the Effects of Education Interventions into More Readily Interpretable Forms*. (NCSER 2013-3000).

[b]Hattie, J . (2009). *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. Routledge.

The Sweat:
How Did We Get There?

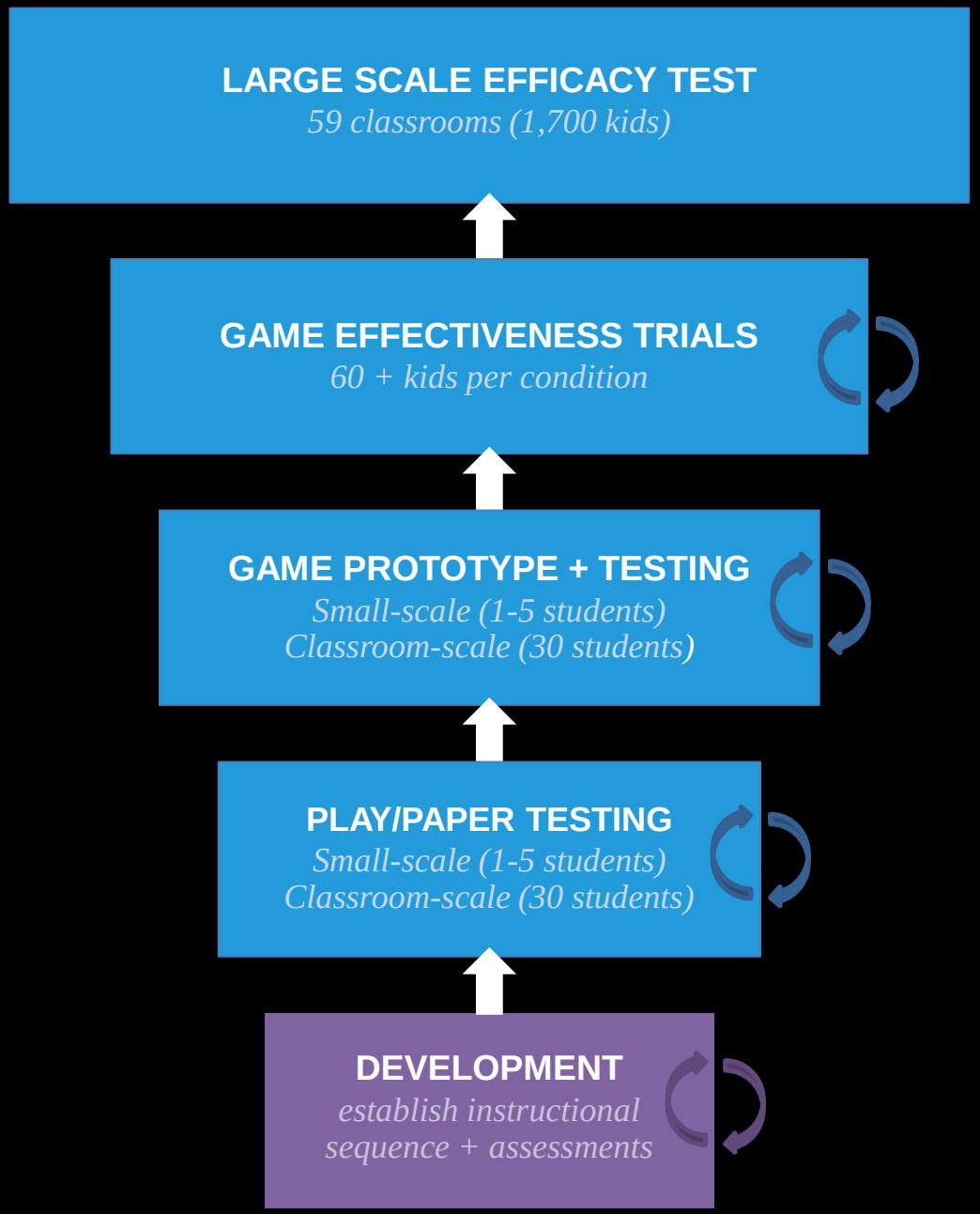
RCT Launch Schedule



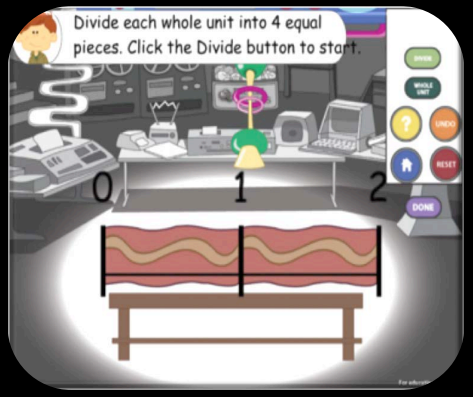
Game Development Studies 2 Years Before RCT

- Total of 24 trials, Grades 4-12
  - ✓ *Setting: Schools, after-school program, private school*
    - ❖ *18 sites; 8 school districts; 4 states*
- Types of studies
  - ✓ *Small scale tryouts: pre-post, think-alouds*
    - ❖ *7 Studies; total N=238*
  - ✓ *Experimental studies: Instructional variations*
    - ❖ *10 studies; total N=1588*
    - ❖ *Typically 30-40 minutes*
  - ✓ *Assessment and methodology studies*
    - ❖ *7 studies; experimental data plus 711 new subjects*

Game Development and Testing Process



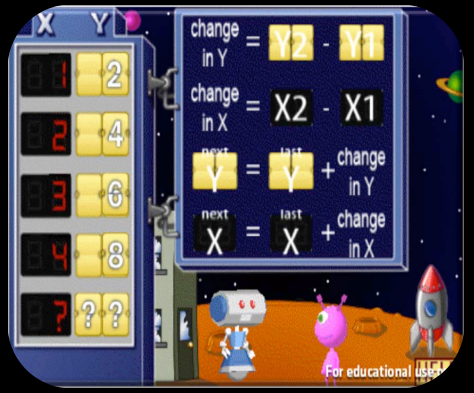
Fractions Games



WikiJones
(number line)

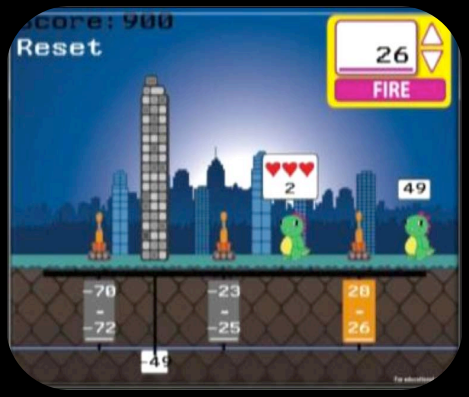
Save Patch
(unit, fractional pieces, adding fractions)

Tlaloc's Book
(inverse operations)



Rosie's Rates
(functions)

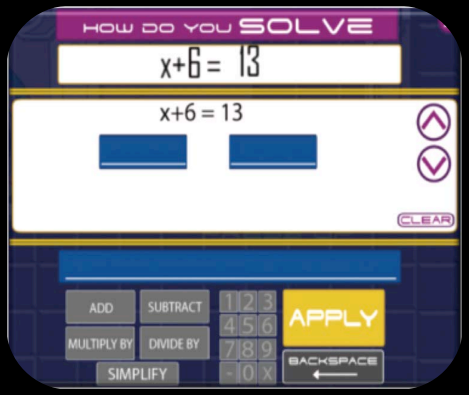
Solving Equations Games



MonsterLine
(operations on pos. and neg. integers)

Expresso
(transforming expressions)

Zooples
(solving equations)



AlgebRock
(solving equations)

Game Development Studies Results

- Empirical
  - ✓ *Instruction/feedback – less is more, narrative and avatar choice matters for engagement, collaboration helpful for low performers, repeated play improves learning, math measure validation, engagement scale validation, misconceptions and play strategies detectable via data mining, …*
- Student and teacher self-reports, classroom observations
  - ✓ *Game features – music, graphics, chevos, avatar select*
  - ✓ *Math not really an issue, high engagement, surprises*
  - ✓ *Technology issues*

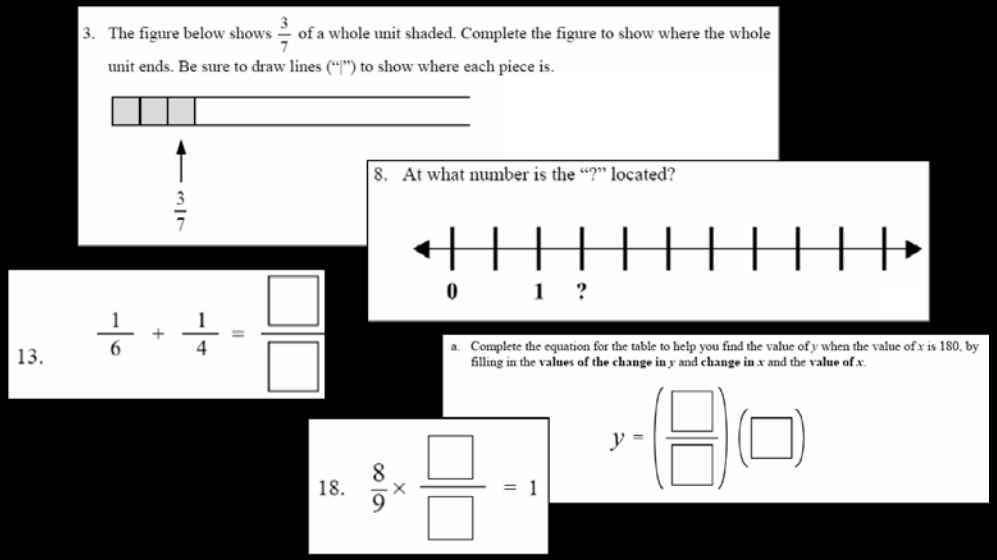
Game Development Studies Results

- Developing games for learning -- hard but doable
  - ✓ *Big difference between teaching and practice*
  - ✓ *Games don't have to be AAA quality*
    - ❖ *Classroom context sets a low bar*
  - ✓ *Stickiness possible -- the more challenging, the more sticky*
  - ✓ *Game mechanics that require use of knowledge is a key design feature*
  - ✓ *Anecdotal collateral benefits of gameplay -- more student engagement, more individual attention, better feedback to teacher, increased confidence of student, productive student-student interactions*

The Tears:
Impact and Innovations

Impact: Developed learning effective games

- Kids learned something from our fractions games as measured by an external *transfer* test

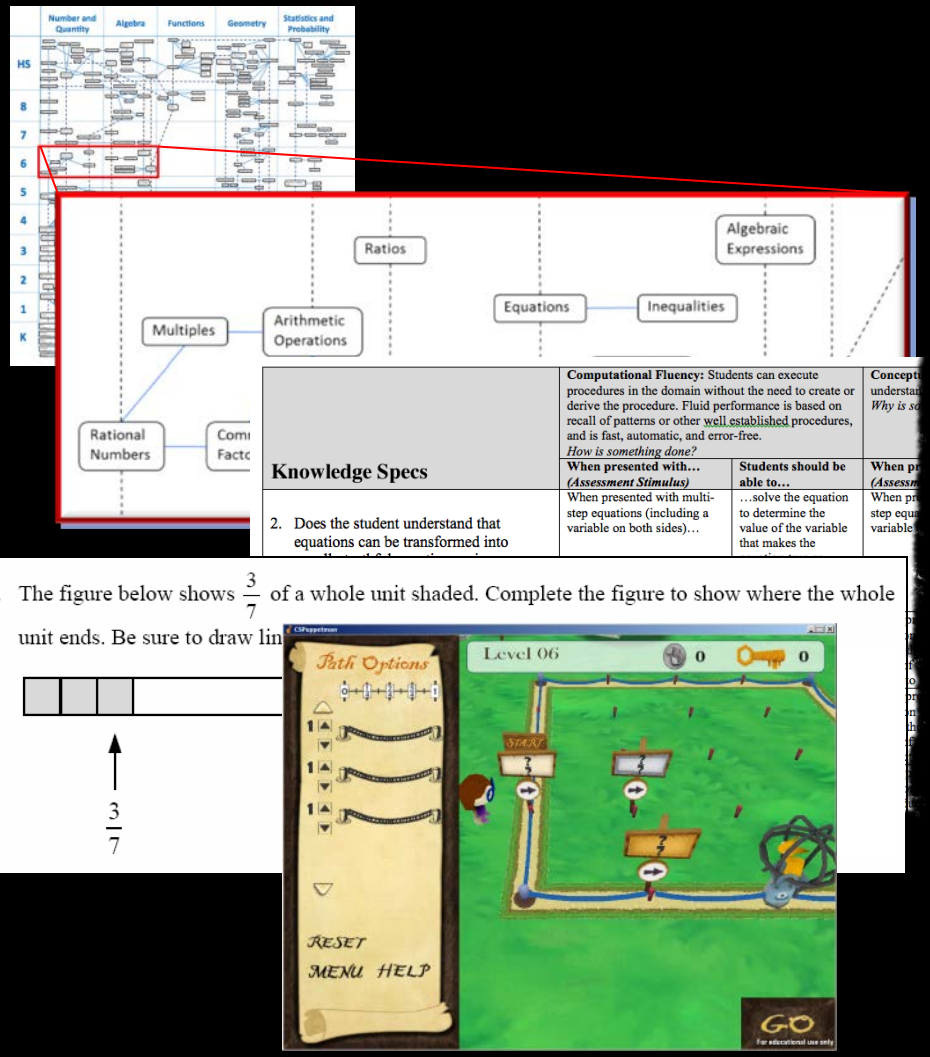


Other Impacts

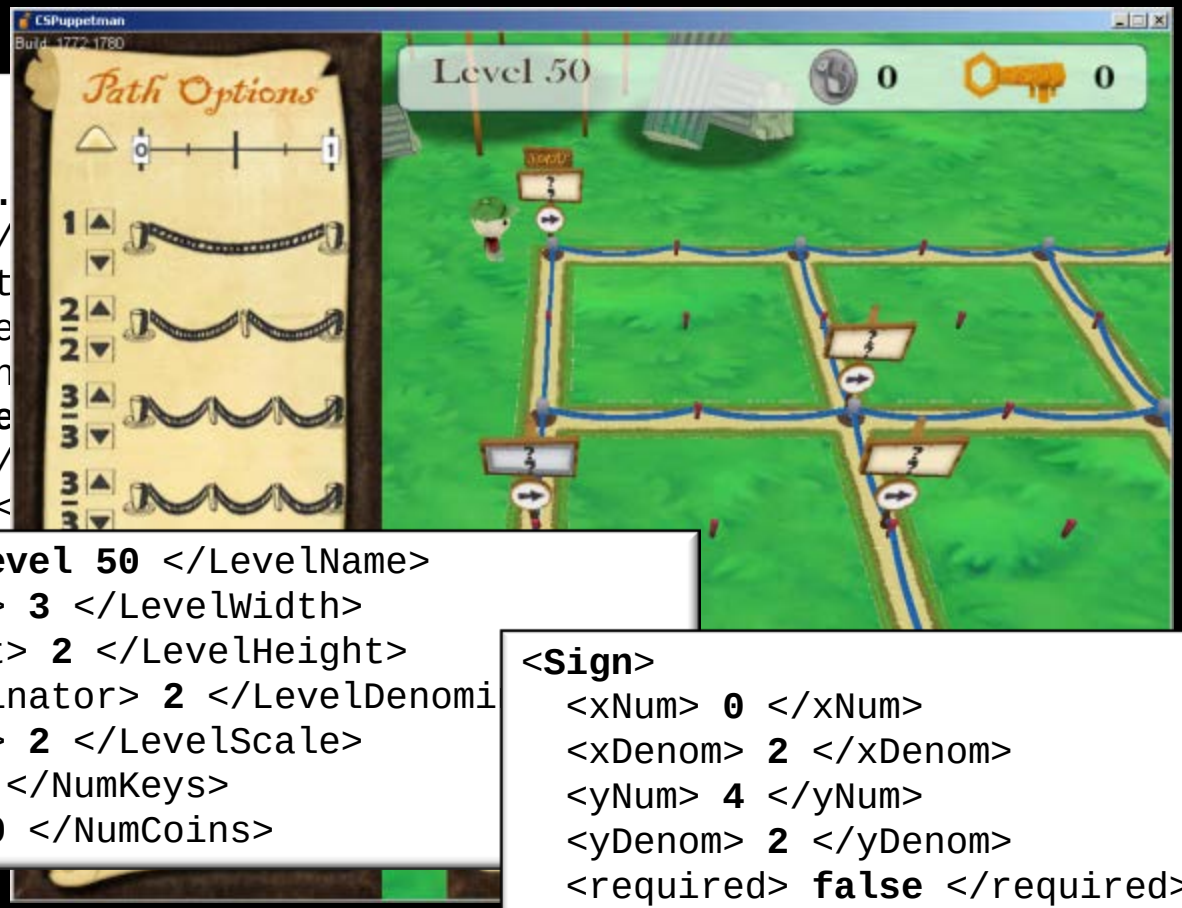
- New methodology
  - ✓ *See Cai presentation, 10:45-12:15pm session*
- Technical reports craziness
  - ✓ *CATS technical reports downloaded 69,456 times*
- Journals (15), proceedings (7), chapters (9), technical reports (22), conference presentations (93)
- Transfer of CATS-based approaches and methodologies to other game-focused projects at CRESST (DARPA, ONR, PBS KIDS, CSUSB, …)

Innovation: Coherent Design Process

- Ontologies and knowledge specifications
- Game design, assessment, professional development
- Guides what to teach in game, what to measure, what to focus on in professional development



Innovation:
Game Testbed to Accelerate R&D

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  <LevelScale> 2 </LevelScale>
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  <start> true </start>
</Sign>
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Innovation: Gameplay as a Data Source

- Key design properties
  - ✓ *Game telemetry reflects description (not inferences) about events connected to learning*
  - ✓ *Game telemetry packaged in a structured format (i.e., usable)*
  - ✓ *Game mechanic requires use of math knowledge*
  - ✓ *Game allows player to fail (i.e., commit errors)*
  - ✓ *Game requires player to make decisions (do I do this or that?)*
  - ✓ *Player cannot progress without requisite knowledge*
  - ✓ *Stage / level design useful [stages = 1 concept; levels = variations of concepts]; sawtooth curve*

Dear UCLA, ever sence 1st grade(Im not lieing) ive never been good in math. But im not stupid not at all. Your games have taught me alot. I want to thank all you guys for helping me out with my struggle with math.

Many thanks~

center for advanced technology in schools

cats.cse.ucla.edu

cresst.org