INSTRUCTIONAL GAMING: USING TECHNOLOGY TO SUPPORT EARLY MATHEMATICAL PROFICIENCY

*Center on Teaching and Learning*
University of Oregon

Marshall Gause
*Thought Cycle, LLC*

Scott K. Baker
*Southern Methodist University*

Society for Research on Educational Effectiveness
2013 Fall Conference
PRESENTATION OUTLINE

- Background and Rationale for Instructional Gaming in Mathematics
- NumberShire Project Aims & Scope
- NumberShire Development Process
- Recent Feasibility Research
- Implications for Instruction, Curriculum Design, & Research
NUMBERSHIRE PROJECT STAFF

CTL
- Hank Fien
- Chris Doabler
- Nancy Nelson Walker
- Ben Clarke
- Melinda Sota
- Maria Kalnbach
- Holle Bauer Schaper
- Sarah Crabtree
- Nick Phillips

Thought Cycle
- Marshall Gause
- Michael Mack
- Patrick Brott
- Greg Reinmuth
- Gabe Soria
- Jacob Voll
- Trevor Dilley
- Kelle DeForrest
- Anthony Bruno
The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R324A120071 to the University of Oregon and SBIR funds to Thought Cycle, LLC. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.
A CALL FOR TECHNOLOGY IN EDUCATION

- National Education Technology Plan 2010 (NETP):
  - “Technology should be used to support student interaction with STEM content in ways that promote deeper understanding of complex ideas, engage students in solving complex problems, and create new opportunities for STEM learning throughout our education system” (p. xvi; NETP, 2010).

- The Plan addresses five essential areas for leveraging technology to improve our education system:

1. Learning: Engage and Empower
2. Assessment: Measure What Matters
3. Teaching: Prepare and Connect
4. Infrastructure: Access and Enable
5. Productivity: Redesign and Transform
WHY TECHNOLOGY FOR MATHEMATICS EDUCATION?

- There is widespread concern about the persistent low mathematics achievement of students in the US, particularly for students from low-income and minority backgrounds and students with disabilities:
  - Only 40% of 4th graders scored at or above Proficient in mathematics on the 2011 National Assessment of Educational Progress (NAEP)
  - Approximately 50% of 4th graders with a disability scored Below Basic
- Students that perform poorly in math in the early grades are likely to continue to struggle academically (Morgan et al., 2009)
INSTRUCTIONAL GAMING TECHNOLOGY: A POTENTIAL SOLUTION

- Instructional gaming technology, when designed and fictionalized well, can be a valuable tool for supporting students with or at risk for LD in math in developing mathematics proficiency because of its capacity to:
  - Increase the intensity of instruction (Gersten et al., 2009)
  - Differentiate instruction to meet the needs of the full range of students (Fien et al., 2011).
  - Motivate students who have experienced a long line of failure and frustration (Ryan et al., 2006)
THE NUMBERSHIRE PROGRAM OF RESEARCH

- Kindergarten: Institute of Education Sciences (IES) Development and Innovation Project
  - 7/1/2012 – 6/30/2015: $1,500,000

- Grade 1: SBIR Fast Track Award (Phases I & II)
  - 7/1/2011 – 12/31/2013: $1,050,000

- Grade 2: SBIR Phase I award
  - 7/1/2012 – 12/31/2012: $150,000

- Grade 2: SBIR Phase II award
  - 6/1/2013 – 5/31/2015: $900,000
NUMBERSHIRE PROJECT AIMS

- Develop a full K-2 suite of educational tools that employ advanced gaming technology specific to early mathematics instruction
- Support all students, especially those who are at risk for mathematics difficulties in developing mathematical proficiency in whole number concepts identified in the Common Core State Standards in Mathematics (2010)
  - NumberShire will be flexibly designed to serve as (1) a supplement to a core program, (2) in conjunction with an existing math intervention (e.g., FUSION or ROOTS, Tier 2 print-based math intervention programs developed at CTL), or (3) as a stand-alone Tier 2 or Tier 3 program.
- Build and maximize student engagement, interest, and motivation in foundational, early mathematics content
NUMBERSHIRE FEATURES

- NumberShire (NS) is set in an idyllic, Renaissance-themed world.

- Each NS version (K-2) features unique characters, narrative goals, and visual and reward content.

- Instructional weeks (4 days per week) feature big events (e.g., village puppet show, parade, masquerade ball).

- Students are able to customize their village and outfit their avatar with fun costumes.
THE PARTICULARS OF NUMBERSHIRE

- Approximately 12 hours of game play per grade level
  - 15-min sessions; 4 days per week for approximately 12 weeks

- Sessions target critical math content:
  - Focus on CCSS-M whole number concepts (Counting and Cardinality, Number and Operations in Base Ten, Operations and Algebraic Thinking)

- Activities use an explicit instructional approach to introduce and review concepts and ideas:
  - Utilize explicit modeling and supported and independent practice opportunities, across deliberately sequenced activities
  - Employ visual models of math ideas to build a robust conceptual foundation of mathematical learning
THE PARTICULARS OF NUMBERSHIRE

- Interface generates data to inform adjustments to gameplay and classroom instruction:
  - Differentiated Learning Pathway provides targeted practice and review
  - Students receive feedback about performance in the form of rewards and access to activities
  - Data reports provide teachers and coaches with information about student learning of instructional objectives targeted in sessions
  - Instructional recommendations, linked to data reports, provide strategies and routines teachers can use to teach or reinforce skills students are struggling to learn
RESEARCH DESIGN

- Engineering NumberShire through design experiment methods (Brown, 1992; Shavelson et al., 2003)

- A sequence of design-analysis-redesign for engaging in a iterative cycle of development (e.g., Common Guidelines)

- Three interconnected activities:
  - Development
  - Implementation
  - Revision
NumberShire
Implementation Research: Feasibility & Usability Studies

SPRING 2013
IMPLEMENTATION STUDY FOCUS

Test the initial feasibility and usability of the NumberShire K-2 system, in the context of a week of game play (SBIR Phase II RFA)

- Initial “evidence on the feasibility that end users can implement the intervention in an authentic education or learning setting” (IES& NSF Common Guidelines for Design & Development Research, p. 20)

Research questions were:

1. Is NumberShire reliably efficient and easy for students to use, and can it be deployed in authentic school settings?
2. Are students able to focus on and benefit from mathematics content in the game, rather than being distracted by other features?
3. Are students operating the game as intended?
4. How do students rate their NumberShire experience? Are students engaged with NumberShire mini-games and activities?
SETTING

School A - a diverse, large, urban charter school in Boston, MA
- Primary languages: Spanish, Creole, Portuguese, English
- In-building math support: 2 math coaches
- Well-equipped, up-to-date computer lab (PCs)

School B – a diverse, large suburban K-8 school in Portland, OR
- 85% of student population receives FRPL
- Primary language: English; 50% of pop is ELs
- Several computer labs, with a range of technology resources (Macs)
PARTICIPANTS

- Kindergarten students \((n = 91)\)
  - Four classrooms (2 in School A, 2 in School B)
- Grade 1 students \((n = 143)\), from four classrooms
  - Six classrooms (2 in School A, 4 in School B)
- Risk Status
  - Kindergarten = 23%, based on teacher and coach perception and AIMSweb screening assessment data
  - Grade 1 = 36%, based on Pretest performance (<40th %ile)
PROCEDURES

- Each classroom engaged in four 30-minute testing sessions over the course of one week
  - 15 minutes devoted to student game play
  - 15 minutes used for assessment and interviews

- Research staff facilitated all testing activities
  - Ensured school-based machines could run Unity (internet-based platform)
  - Administered and scored all research instrumentation
  - Conducted student and teacher interviews
DATA SOURCES

► Game metrics used to gauge student *accuracy* and *latency* during game play

► Proximal measure of mathematics skill administered to first grade students at pretest and posttest (paper-pencil)
  ▶ Items targeted concepts taught in the target week’s sessions (i.e., multi-digit addition and equality)

► Student interviews (large and small groups)
  ▶ Recalled math activities and storyline events
  ▶ Commented on game preferences (e.g., rewards)

► Teacher interviews
  ▶ Perceptions of student interest in NS, alignment of NS with essential math content

► Direct observations of student game play
  ▶ Navigation of interface, sustained engagement
PROXIMAL ASSESSMENT

- Paired t-tests used to examine gains in student math outcomes during feasibility testing
  - Total score gain from pretest ($M=16.19, SD=5.06$) to posttest ($M=17.27, SD=3.91$) was significant, $t(135)=4.03, p < .001$.

- Preliminary findings suggest students made improvements in skills targeted for instruction during the feasibility test
OTHER PRELIMINARY FINDINGS

► Students:
  ► Were able to recall math-related activities and gaming aspects of NS
  ► Appeared to be actively engaged and interested in NumberShire
  ► Were able to:
    ► Navigate the game interface via a mouse (but had more difficulty using a track pad)
    ► Transition from one activity to another
    ► Understand directions provided in the game

► Teachers:
  ► Indicated students were excited about the game (e.g., students asking when they would be able to play again)
  ► Stated that NS targeted important math skills
  ► Expressed interest in obtaining student performance data and customized instructional recommendations
IMPLICATIONS FOR INSTRUCTION, CURRICULUM DESIGN, & RESEARCH

- NumberShire utilizes a replicable methodology for gaming engineers to work with instructional design experts to develop interventions.
- Preliminary data suggest NumberShire activities, as currently designed, may support student learning.
- As students play the game, we are building banks of student performance data that will allow for normative and criterion-based comparisons:
  - Gathering accuracy and latency data during game play, in activities aligned with the CCSS-M.
  - Data will provide an indication of what it means to perform at a certain level in the context of technology-based activities, relative to other students.
  - Future studies of game play will also evaluate game play performance relative to other established measures of achievement.
LIMITATIONS

- Feasibility study employed a quasi-experimental design
  - No control group or random assignment to condition
- Study occurred over one week of game play
  - Expect students to require more than 4 days of intervention to turn the dial on mathematics achievement
- Assessment was very brief and only administered to Grade 1 students
- Researchers facilitated intervention sessions
NEXT STEPS

2013-2014

- NS1 Pilot Study (26 Grade 1 Classrooms) to test promise of 1st grade intervention for improving math learning for students at risk for math difficulties
  - Schools will facilitate NS intervention with training and support
- NSK and NSII Feasibility Studies to systematically test game rewards, student engagement, activity sequencing, and the perceived utility of data reports

2014-2015

- NSK and NSII Pilot Studies in Kindergarten and Grade 2 classrooms
QUESTIONS?

► Contact:
  ► Nancy J. Nelson Walker (nnelson3@uoregon.edu)
  ► Marshall Gause (mgause@thoughtcycle.net)

► Website: http://www.thoughtcycle.net/
http://www.youtube.com/watch?v=nYGe_NOI8V4&feature=youtu.be