Does Negative Integer Instruction Transfer to Negative Rational Numbers?

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Introduction

- Learning about integers is an important part of 4th grade math curricula as addressed by math standards (CA state standards).
- Integers are symmetric around zero, as reflected in their additive inverse property (x + -x = 0) and representation on a number line.
- Behavioral and neuroimaging work suggests the importance of symmetry in understanding integers. In a *purely symbolic* integer bisection task (e.g., find the midpoint of -3 and 7), the degree of symmetry around 0
  - predicts response time (Tsang & Schwartz, 2009).
  - positively correlates with brain activation in regions involved in detecting *visual* symmetry (Tsang, Rosenberg-Lee, Blair, Schwartz, & Menon, 2010).
- Does explicit instruction about symmetry affect students' learning of integers? We ran a study comparing symmetry instruction with other standard approaches.

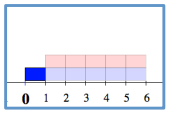
Instructional Approach	Mathematical Principles
Counting on a number line	Ordinality, operations
Cancellation	Set theory, additive inverse
Symmetry	Additive inverse, symmetry

Materials

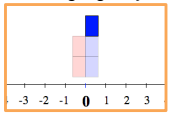
- Three curricula featuring tangible manipulatives (blocks) and digital representations (computer games) were designed to emphasize different properties of negative numbers and their relationship to positive numbers.

Number line and cancellation taught separately
- Similar to traditional instruction

Number line and cancellation taught simultaneously
- Integration of two traditional approaches



Symmetric cancellation about zero
- New curriculum designed to highlight symmetry around zero



Methods

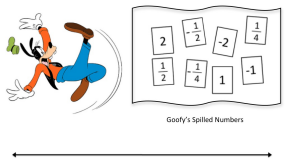
Participants
- 68 4th grade students from a suburban elementary school

Study Design
- Participants were drawn from three 4th grade classrooms.
  - Students were stratified based on standardized test scores and were randomly assigned to three new instructional groups.
  - Each instructional group was split into two halves that were taught separately everyday.
  - Each half-group was comprised of approximately 14 students.
- Pre-post design with 6 days of intervening instruction
  - 40 minutes of class time with each group per day of instruction
  - Manipulative use (blocks)
  - Digital representations (computer gameplay)

Measure

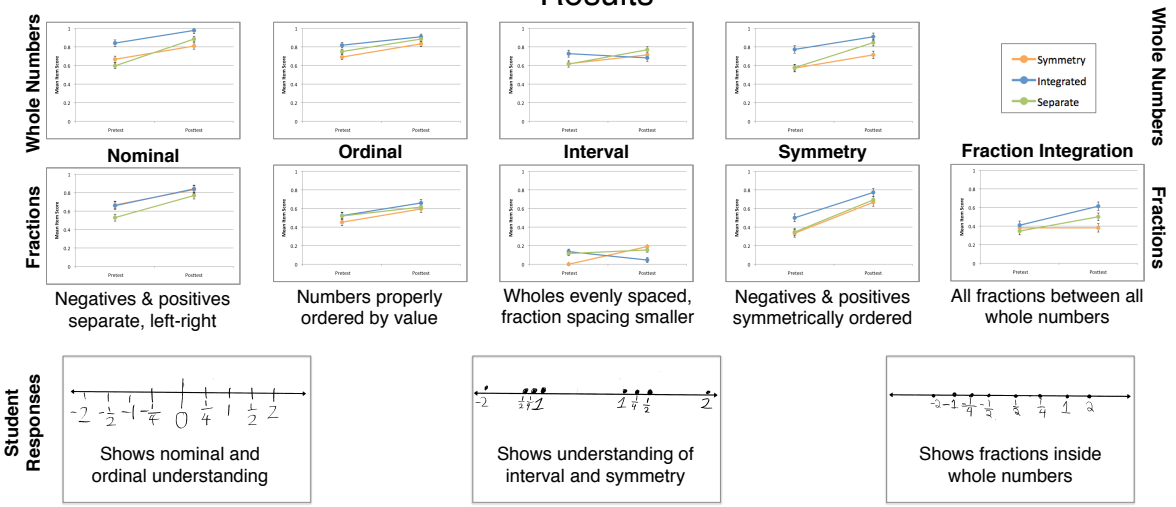
Oh no! Goofy was carrying a number line that showed positive and negative numbers. He tripped and the numbers fell off!

Help Goofy put the spilled numbers where they belong.



- Administered at pre- and post-test in a battery of integer questions
- Focuses on ability to create a number line
- Includes fractions as well as whole number integers
  - More complexity that recreating the practiced representation
  - Reveal differences in ability to think generatively in new contexts

Results



Conclusions

- From pre- to post-test, all groups improved their knowledge of several dimensions of integer relationships.
- Our integer curricula provide deep understanding that is transferable to novel contexts (fractions).
- By focusing on abstract concepts, the symmetry condition may not have made categorical properties as salient as the other conditions.
  - Both other conditions spent time counting on the number line which may be reflected in their performance.

Future Directions

- Work with another coder to verify inter-rater reliability
- Consider student number line results in the context of other pre- and post-test measures like integer arithmetic and symbolic symmetry questions (e.g. ✪ + -✪ = ?)
- Refine instruction and assessment to better investigate the role of symmetry in preparing students for abstract math concepts

References

Tsang, J.M., Rosenberg-Lee, M., Blair, K.P., Schwartz, D.L., & Menon, V. (2010, June). *The neural and educational basis of integer representations: Symmetry.* Poster session presented at EARLI-SIG "Neuroscience and Education" Meeting, Zurich, Switzerland.
Tsang, J.M. & Schwartz, D.L. (2009) Symmetry in the Semantic Representation of Integers. *Cognitive Science*, 323 – 328.