Filling in the Gaps: Creating an Online Tutor for Fractions

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Problem

"Difficulty with fractions … is a pervasive and major obstacle to further progress in mathematics, including algebra" (National Mathematics Advisory Panel, 2008)

Difficulty may stem from multiple representations of fraction knowledge:
Kieren's (1976) 5 property model
part-whole, ratio, operator, quotient, measure

Instructional Response

Little agreement among educators and curricula

However, number line estimation-based curricula elicit greater performance gains on estimation and equivalence problems, on conceptual questions about fractions and on transfer fraction arithmetic tasks than fair-sharing models (Rittle-Johnson, Siegler & Alibali, 2001; Keijer & Terwel, 2003)

Representations often only show fractions less than one

Research Question

How does presentation order of proper and improper fractions impact students' understanding of fractional magnitudes?

"Conceptual and procedural knowledge about fractions with magnitudes less than 1 do not necessarily transfer to fractions with magnitudes greater than 1" (National Mathematics Advisory Panel, 2008)

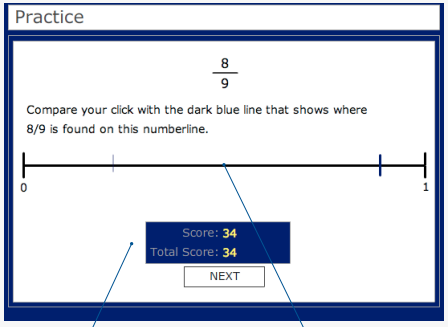
Learning Environment Design

Computer-based environment featuring short textual fraction instruction section followed by number line estimation practice

Two number line practice contexts
Proper fractions less than one
0-1 number line

Mixed numbers between 1 and 5
0-5 number line

Practice Question Interface



Feedback: Points, calculated as 100 - percent error

Feedback: Response colored on gradient as function of points, dark blue hatch mark for correct answer

Proposed Experiment

Between-subjects design
Independent variable:
Learning practice environment
(Mixed number or proper fraction)

Hypothesis
Mixed number practice condition will more easily generalize knowledge on transfer tasks than proper fraction practice condition

Learning Material Considerations

Item Selection
All numerators and denominators drawn from single-digit numbers (1-9)
Only reduced fractions included
1/2 not included

Only number line endpoints were labeled, no whole numbers marked

All number lines were equally sized and spaced, regardless of endpoint range

Pre- and posttest measures: 4 estimation tasks

Number line	0 – 1	0 – 5	0 – 5	0 – 10
Fractions	Less than 1	Less than 1	1 – 5	0 – 10
Group A Proper Fractions	Same as practice	New line Same numbers	New line New numbers	Far Transfer
Group B Mixed Numbers	New line New numbers	Same line New numbers	Same as practice	Far Transfer

References

Keijer, R. & Terwel, J. (2003). Learning for Mathematical Insight: A Longitudinal Comparative Study on Modeling. *Learning and Instruction, 13*, 285-304.

Kieren, T. E. (1976). On the mathematical, cognitive, and instructional foundations of rational numbers. In R. Lesh (Ed.), *Number and Measurement*, Columbus: Ohio State University, EEIC, SMEAC. pp. 101 – 144.

National Mathematics Advisory Panel. (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*, U.S. Department of Education: Washington, DC.

Rittle-Johnson, B., Siegler, R. S., & Alibali, M. W. (2001). Developing Conceptual Understanding and Procedural Skill in Mathematics: An Iterative Process. *Educational Psychology, 93(2)*, 346 – 362.