The Effects of Visual Representations and Interest-Based Personalization on Solving Percent Problems

Dr. Candace Walkington, Southern Methodist University
Dr. Jennifer Cooper, University of Wisconsin – Madison
Elizabeth Howell, Southern Methodist University

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

SMU | ANNETTE CALDWELL SIMMONS SCHOOL OF EDUCATION & HUMAN DEVELOPMENT

CHANGING MINDS

Introduction

- Mathematics story problems are sometimes considered notoriously difficult (Cummins et al., 1988)
- Yet story problems can play an important role in mathematics learning (Walkington, Sherman, & Petrosino, 2012):
  - Provide **access** to mathematical ideas through **grounding** (Goldstone & Son, 2005) in verbal or situational knowledge
  - Enhance motivation for or **interest in** engaging with mathematics (Hidi & Renninger, 2006)

Context Personalization

- Match topics of story problems to topics students are interested in (e.g., sports, video games, social networking)

"You can have a whole bunch of people follow you, you can follow people and count your likes. And if you put hashtags sometimes you can get a whole bunch of likes. And there's like "Instagram famous" people who have like 25k followers. If I do hashtags, I get anywhere from 30 to 50 or 60 likes. Sometimes I put like 10 or 11."

Context Personalization

- Match topics of story problems to topics students are interested in (e.g., sports, video games, social networking)

> *Nancy has 115 followers on Instagram. She wants to become "Instagram Famous," so she uses hashtags to get more attention when she posts pictures. If Nancy gets 15 additional followers for every hashtag she uses in a post, write an equation relating number of hashtags to her total number of followers.*

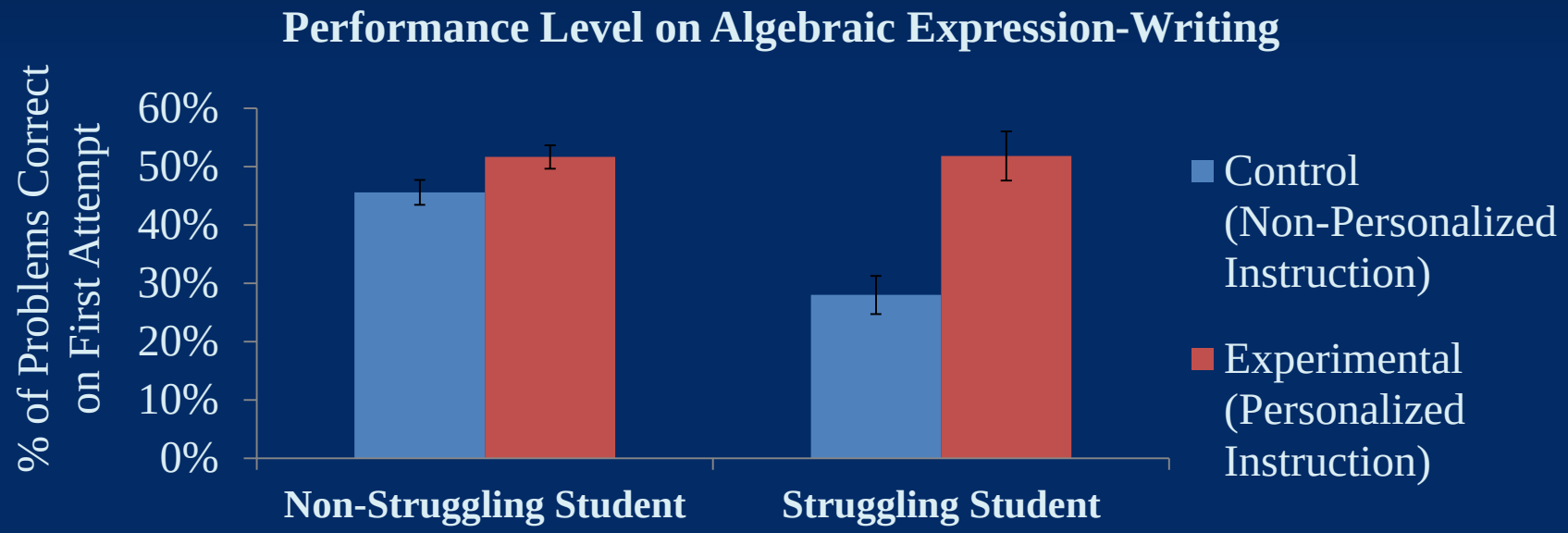
- Personalization improves immediate performance and **transfers** to non-personalized problems involving **more sophisticated concepts** (Walkington, 2013)

Visual Representations

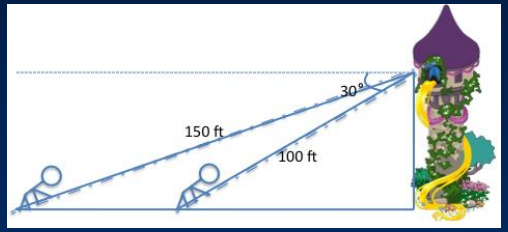
- Visual representations (e.g., diagrams, illustrations) can support or hinder students' problem solving (Booth & Koedinger, 2012; McNeil et al., 2009)
  - *Grounding:* Familiarity could allow easier integration of background story with prior knowledge (e.g., Goldstone & Son, 2005; Koedinger & Nathan, 2004)
  - *Multimedia effect*: Words and pictures are better than words alone (Butcher, 2006; Mayer & Anderson, 1992; Mayer, 2009)
  - *Coherence principle:* Extraneous features overload available cognitive processing (e.g., Harp & Mayer, 1997, 1998)

Student Background Characteristics

- Personalization most effective for academically struggling students (Walkington, 2013; Walkington, Petrosino, & Sherman, 2013)



Student Background Characteristics



- Diagrams helped all students on trigonometry problems while effect of illustrations depended on math/science major (Cooper & Alibali, 2012)
  - Diagram comprehension skills may not be well developed among lower-achieving students (Booth & Koedinger, 2012)
- Mixed or neutral findings on problem solving performance when removing decorative illustrations, affected by prior knowledge (Clinton et al., 2013; Cooper et al., 2013)

Research Questions

1) What are the effects of personalization and visual representations (diagrams, illustrations) on students' accuracy when solving percentage story problems?

2) How do these trends change when taking into account students' self-reported levels of affect towards mathematics and knowledge of mathematics?

Participants & Procedure

- *N* = 139 7th grade students, suburban Southern middle school
- 43% female, 57% male
- School predominantly Caucasian (46%) and Asian (30%)
- 12% eligible for free/reduced lunch and 3% classified as Limited English Proficient
- Students solved 8 problems on a worksheet during math class, along with a background survey

Percentage Problems

A Southwest Airlines passenger plane can seat 98 passengers. On the Monday flight there were 63 passengers. What percent of seats on the plane have passengers in them?	$\frac{63}{98} = \frac{\%}{100}$
The Pelican's Club printed color fliers for an upcoming event. They prepared 1468 fliers to distribute. 1282 fliers were passed out. What percent of the fliers are left over?	$\frac{1468 - 1282}{1468} = \frac{\%}{100}$
Shawn has been shopping for a new office chair. The retail price for the office chair that Shawn likes is $254. On Friday the chair will go on sale for 20% off of the price. How much will Shawn pay for the office chair if he purchases it on Friday with the sale (excluding tax)?	$\frac{x}{254} = \frac{100 - 20}{100}$
Rene is going to volunteer her time at the local library. She will spend 15% of her volunteer time shelving books. If she has committed to work at the library for 48 hours, how many hours will she spend shelving books?	$\frac{x}{48} = \frac{15}{100}$

× 2 versions of each = 8 total non-personalized versions

Factor 1: Personalization

- Prior to study, students rated interest in 7 topics (*sports*, *music*, *food*, *games*, *shopping, cell phones*, *computers*) and in subtopics
- We wrote personalized versions of original problems for each most popular sub-topic
- Problems assigned to students based on their highest ratings

	Boring	They're Okay	Like Them	They're my Favorite Thing
Sports				

1) Which sports do you like to play or watch? (check all that apply):

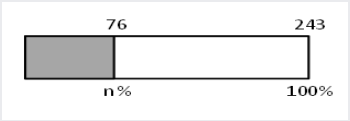
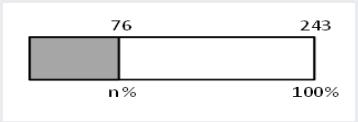
___ Soccer ___ Football ___ Track ___ Swimming ___ Baseball ___ Tennis

___ Cheerleading/Gymnastics ___ Basketball

Factor 1: Personalization

YouTube: So far 98 people have viewed a new YouTube video that Hank posted. Hank noticed that 63 of the people who viewed the video also "Liked" it. What percent of the people who viewed the video also "Liked" the video?	$\frac{63}{98} = \frac{\%}{100}$
Pop music: Bruno Mars is coming to Dallas for a concert. There were 1468 tickets sold to the concert. Of those tickets sold, 1282 were sold to teenagers. What percent of the tickets were sold to non-teens?	$\frac{1468 - 1282}{1468} = \frac{\%}{100}$
Clothes shopping: Heather went shopping at Banana Republic. Her total bill was $254. Heather had a sale coupon for 20% off of her total purchase, and gave the coupon to the cashier. What will Heather's new total be with the sale coupon (without tax)?	$\frac{x}{254} = \frac{100 - 20}{100}$
Basketball: Sam is on the Liberty basketball team. He has completed 15% of his required practice time this month. If Sam's coach requires the players to practice 48 hours each month, how many hours has Sam practiced?	$\frac{x}{48} = \frac{15}{100}$

Factor 2: Visual Representations

	No Illustration	Illustration
No Diagram	Kris worked 243 days last year. His work required that he travel 76 of those days. What percent of the time was Kris out of his office?	Kris worked 243 days last year. His work required that he travel 76 of those days. What percent of the time was Kris out of his office? 
Diagram	Kris worked 243 days last year. His work required that he travel 76 of those days. What percent of the time was Kris out of his office? 	Kris worked 243 days last year. His work required that he travel 76 of those days. What percent of the time was Kris out of his office?  

Each student had 2 problems (1 personalized, 1 non-personalized) in each visual condition.

Factor 3: Student Background

- 12-item questionnaire about math attitudes; EFA revealed 3 factors:
  - ***Knowledge*** about mathematics (“I find math confusing”)
  - ***Affect*** for mathematics (“I find many math problems interesting”)
  - ***Value*** for mathematics (“Math is important in everyday life”)

Knowledge →

Affect ↓

Low Knowledge, Low Affect	**High Knowledge, Low Affect**
Low Knowledge, High Affect	**High Knowledge, High Affect**

Analysis Techniques

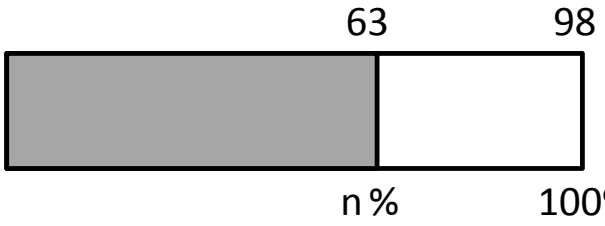
- Logistic regression models predicting whether student got problem correct or incorrect (0/1)
  - Presence of personalization, diagram, and illustration
  - mathematical knowledge and mathematical affect (high or low)
  - Random intercepts for student, teacher, and four question structures
- Model selection was based on the model comparison (chi square on likelihoods)

Results – RQ1

Diagrams were superior to text alone (p = .007),
Illustrations were marginally better than text alone (p = .06), and
Diagrams and illustrations combined were equivalent to text alone

BETTER

A Southwest airlines passenger plane can seat 98 passengers…



WORSE

A Southwest airlines passenger plane can seat 98 passengers. On Monday, there were 63 passengers…

Results – RQ1

Diagrams were superior to text alone (p = .007),
Illustrations were marginally better than text alone (p = .06), and
Diagrams and illustrations combined were equivalent to text alone

BETTER

A Southwest airlines passenger plane can seat 98 passengers…

WORSE

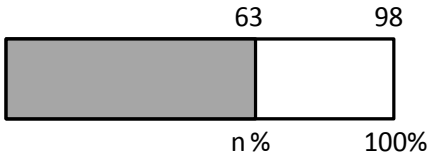
A Southwest airlines passenger plane can seat 98 passengers. On Monday, there were 63 passengers…

Results – RQ1

Diagrams were superior to text alone (p = .007),
Illustrations were marginally better than text alone (p = .06), and
Diagrams and illustrations combined were equivalent to text alone

SAME

A Southwest airlines passenger plane can seat 98 passengers…



SAME

A Southwest airlines passenger plane can seat 98 passengers. On Monday, there were 63 passengers…

Results – RQ1

- The overall effect of personalization was not significant and did not interact with either visual condition (*p*s > .1)

SAME

There are 98 different items on the menu at Carraba's Italian Grill. Sheri and her friends have tried 63 of these items…

SAME

A Southwest airlines passenger plane can seat 98 passengers. On Monday, there were 63 passengers…

Results - RQ2

Knowledge →

Affect ↓

	Low Knowledge	High Knowledge
Low Affect	• No effect for personalization • Illustrations not helpful	
High Affect		• No effect for personalization • Illustrations not helpful

Results - RQ2

Knowledge →

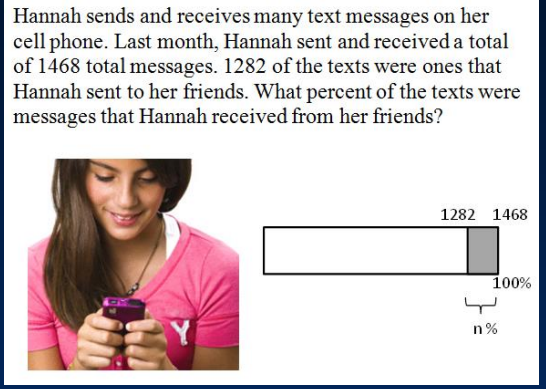
Affect ↓

	Low Knowledge	High Knowledge
Low Affect	• No effect for personalization • Illustrations not helpful	**Personalization** and **illustrations** • each increased performance over text alone (p = .008, p = .001) • ***less effective together*** than either alone (p = .007)
High Affect	**Personalization with illustration** • increased performance over text alone (p=.01) • ***more effective together*** compared to either by itself (p = .038)	• No effect for personalization • Illustrations not helpful

Summary

- Generally, **diagrams** are helpful, provided they are not presented with other scaffolds (i.e., illustration and personalization)
- **Illustrations and personalization** seem to mainly be effective with students who have mixed attitudes towards mathematics (high affect/low knowledge, high knowledge/low affect)
- Although sometimes multiple scaffolds are helpful, usually **one scaffold alone** is best – interact in complex ways
- **Limitations**: Small subgroup sample size, high-achieving population, authenticity of personalization

Implications



- Students need a variety of supports to access and engage with important mathematical ideas in the middle grades curriculum
- Illustrations and personalized contexts have the potential to enhance access by ***grounding*** ideas and by eliciting ***interest*** in the content
  - Combinations of scaffolds are potentially overwhelming
- Need to be aware of potential caveats to these scaffolds, including their **interactions** with each other and with student background characteristics

Acknowledgements

Thank you to **Mitchell Nathan** & **Martha Alibali** for their support of this project!

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grants R305C100024 and R305B100007. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

SMU | ANNETTE CALDWELL SIMMONS SCHOOL OF EDUCATION & HUMAN DEVELOPMENT

CHANGING MINDS

Questions? Comments?

Dr. Candace Walkington, Southern Methodist University cwalkington@smu.edu
Dr. Jennifer Cooper, University of Wisconsin – Madison jcooper4@wisc.edu

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

SMU | ANNETTE CALDWELL SIMMONS SCHOOL OF EDUCATION & HUMAN DEVELOPMENT

CHANGING MINDS