Impact of Professional Development for Math Teachers of English Learners

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Visual Access to Mathematics (VAM) Project

NSF-funded 4-year project, currently in 3rd year

- Intervention: **VAM Professional Development**
  - One-year 60-hour blended-learning course
  - Grades 6-8 math teachers with English Learners (ELs) in their classes
- Cluster RCT to study teacher outcomes

Plan for Today

- Some background

- Professional development intervention

- RQ 1 Measures and Findings

- RQ 2 Measures and Findings

- Summary

Background

Why PD for math teachers of students who are English learners (ELs)?

- ELs' math instruction characterized by **over-emphasis on lower-level content** (Gándara, & Contreras, 2009; Varley, Gutiérrez, Willey, & Khisty, 2011)

- Tendency to **separate language development work from mathematics instruction** (e.g., Firestone, Martinez, & Polovsky, 2006)

- Teachers are not consistently provided **training for how to support ELs to meet content standards** (Bunch, 2013; Darling-Hammond, Wei, & Adamson, 2010; Samson & Collins, 2012)

Importance of Integrating Language and Mathematics

- Math standards place a premium on **communication and academic language**, posing potential challenges for ELs (Bunch, 2013)

- **Integration of language & content** linked to opportunities for ELs to learn math (e.g., Baker et al., 2014, Chval, Pinnow, & Thomas, 2014)

- M**ath teaching practices that "specifically address the language demands of students** who are developing skill in listening, speaking, reading, and writing in a second language while learning mathematics"** (Celedón-Pattichis & Ramirez, 2012, p.1)

Importance of Visual Representations (VRs)

- VRs **enhance mathematical problem solving** (Stylianou, 2002; Stylianou & Silver, 2004; Woodward et al., 2012)

- VRs can **reinforce students' conceptual understanding** of rational number (Gersten et al., 2009; Siegler et al., 2010)

- **Important to study a variety of VRs** and understand how to select representations most appropriate for solving a task (Woodward et al., 2012)

Importance of Visual Representations for students who are English learners

- Provide **bridge between text and symbolic solution** approaches (Ng & Lee, 2009; Baker et al., 2014)

- Support task exploration and **manipulation of quantities from the task**

- Support engagement with the mathematics **at the same time as** language development.

- **Serve as artifacts** to facilitate strategy sharing and negotiation of new ideas

Visual Access to Mathematics Professional Development (VAM PD)

VAM PD: Course Goals

Increase knowledge of how to **create and use visual representations**

Increase mathematical knowledge for teaching of **ratio and proportion** content and key Standards for Mathematical Practice.
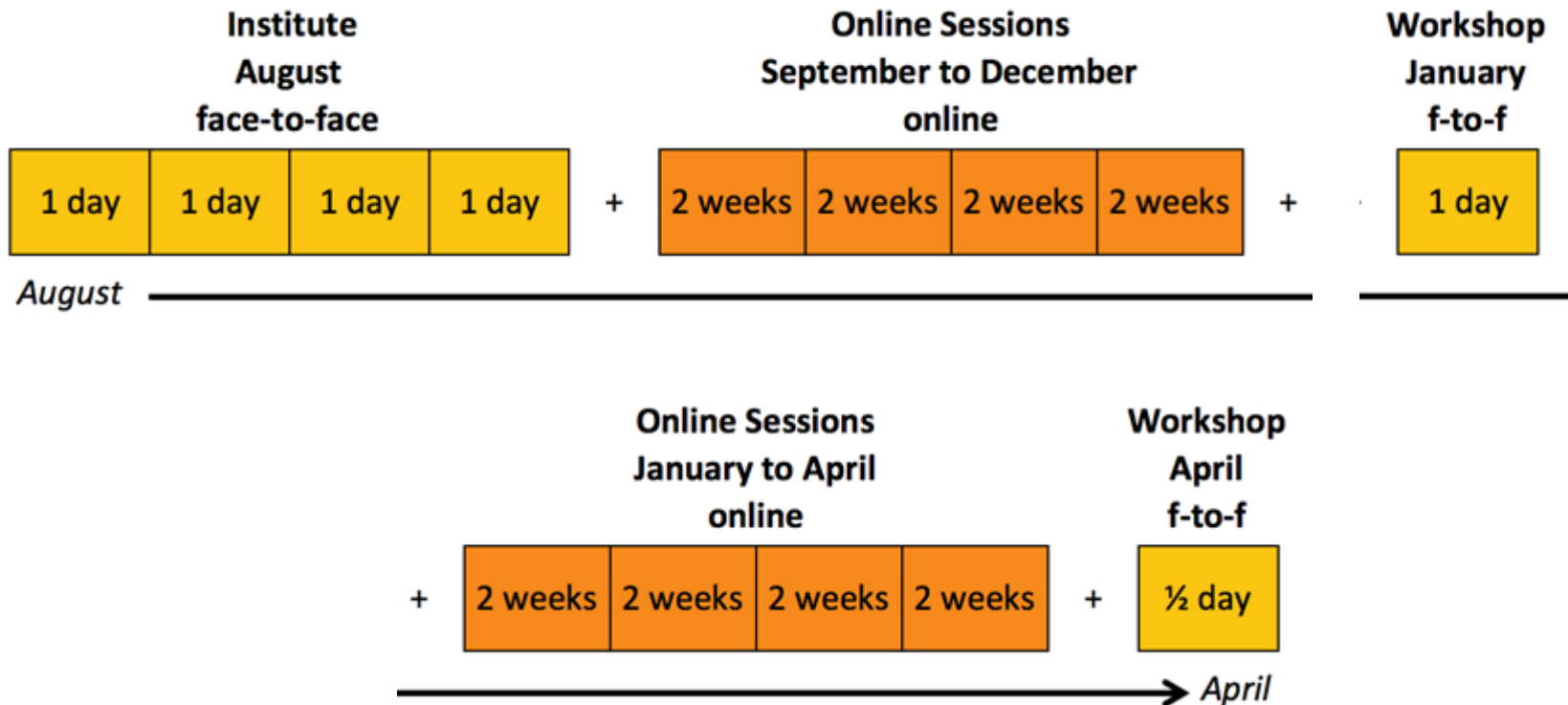
Increase ability to **analyze visual representations to understand student thinking** for ELs

Increase ability to **plan lessons to integrate support for ELs'** (Including language access & production)

Visual | Access to
MATHEMATICS

VAM PD: Course Structure

VAM PD: Visual Representation Focus

- Situated in ratio and proportion content
- Double number lines & tape diagrams
- Thinking tools and communication tools
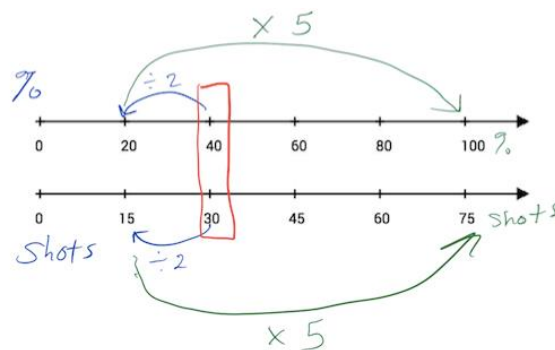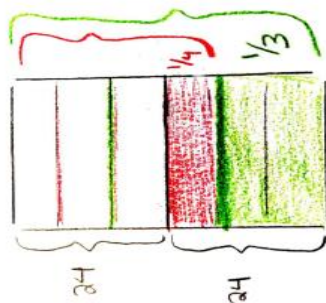
VAM PD: Language Strategy Focus

- Language access strategies (e.g., 3 Reads)
  - Receptive language (listening and reading)
  - Access to engaging with the mathematics

- Language production strategies (e.g., sentence starters)
  - Productive/expressive language (speaking and writing)
  - Participation in mathematical discourse

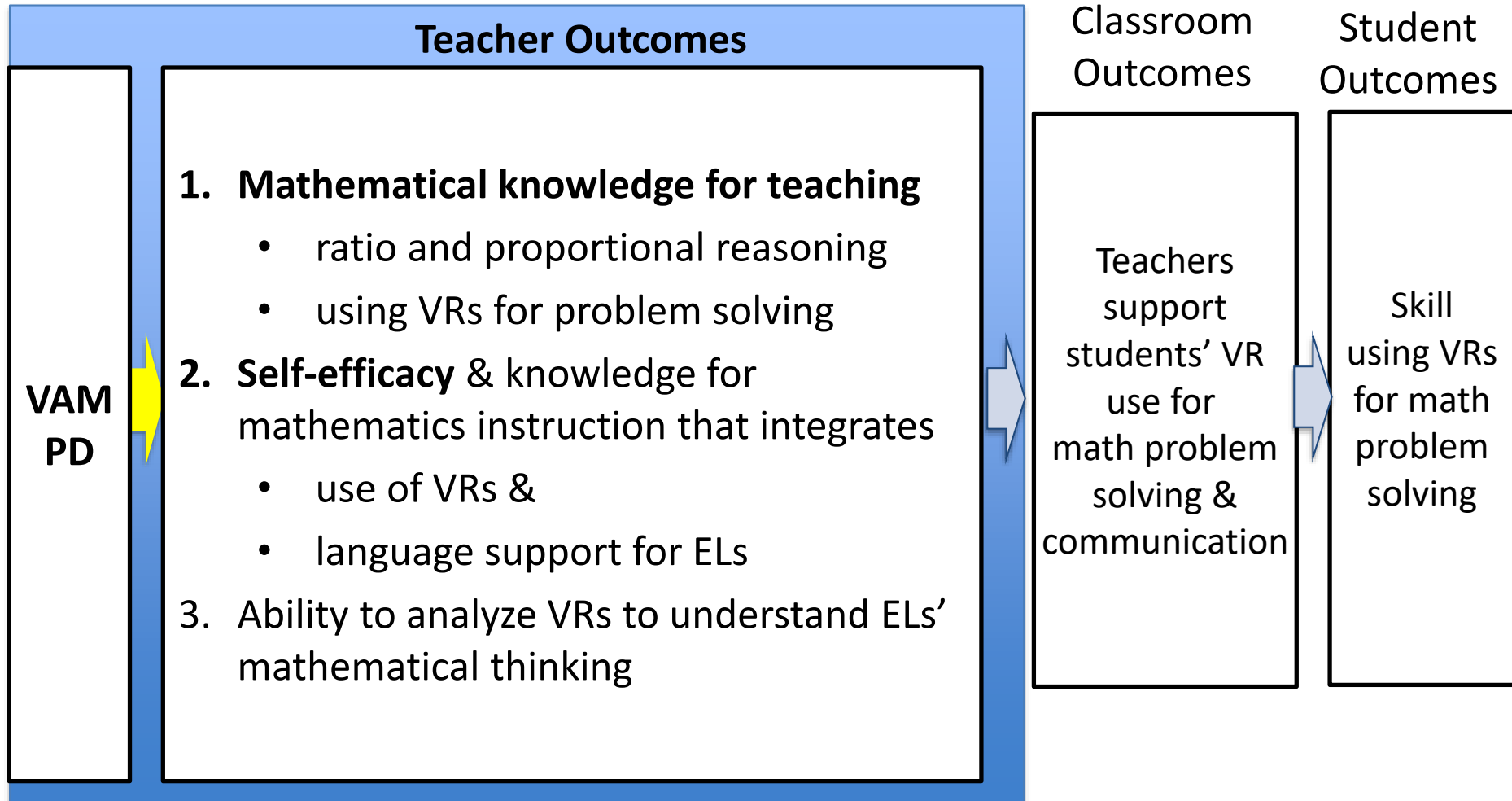- Integrated into mathematics lessons

VAM PD: Core Teacher Activities

- Solve and discuss math tasks with VRs

- Analyze student work

- Learn about supports for language access & production

- Plan and reflect on math instruction for ELs

Theory of Change & Research Questions

VAM Theory of Change

Teacher Outcomes

VAM PD

1. **Mathematical knowledge for teaching**
   - ratio and proportional reasoning
   - using VRs for problem solving
2. **Self-efficacy** & knowledge for mathematics instruction that integrates
   - use of VRs &
   - language support for ELs
3. Ability to analyze VRs to understand ELs' mathematical thinking

Classroom Outcomes

Teachers support students' VR use for math problem solving & communication

Student Outcomes

Skill using VRs for math problem solving

Research Questions

RQ 1: Compared to control teachers, do VAM PD treatment teachers demonstrate greater

- **mathematical knowledge for teaching** ratio and proportional reasoning, and
- **knowledge of using VRs** for mathematical problem solving in this content?

RQ 2: Compared to control teachers, do VAM PD treatment teachers demonstrate greater

- **self-efficacy in using VRs** in mathematics instruction, and
- **self-efficacy for integrating language supports for ELs**?

Research Methods

Study Design

- Cluster randomized trial: balanced design
  - Schools: n=47 (23 T, 24 C)
  - Teachers: n=101 (53 T, 48 C)

- But cluster sizes varied
  - Almost half (n=22) have single participant
  - Remaining clusters have 2-8 participants

Sample Characteristics

Total participants*	
From MA	63%
From ME	26%
Female	90%
White	93%
Teach mathematics (primarily gr. 6, 7, or 8)	67%
Co-taught math with another teacher	66%
Years of teaching experience (mean)	14.4

*Completed all posttests: n=96 (5% attrition overall, 6% T, 4% C)

RQ 1: Mathematical Knowledge for Teaching

Measure of MKT - I

- *Learning Mathematics for Teaching* (LMT) (Ball, Thames & Phelps, 2008; LMT, 2009)
  - 28 multiple-choice items
  - Ratio and Proportional Reasoning scale

- Administered pre- and post-VAM PD

Measure of MKT - II

- *Mathematical Knowledge for Teaching with VRs scale (MKT-VR)*
  - 17 multiple-choice items
  - Targets ratio and proportion content with VRs
  - Assembled from LMT and released items from NAEP, Praxis, MTEL and Campbell et al. (2014)

- Intended for group-level inferences
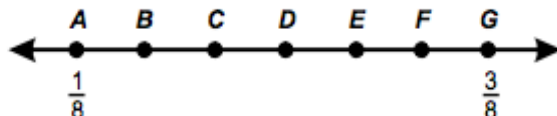- Administered pre- and post-VAM PD

MKT-VR Item 14

Given that the points on each of the number lines shown below are equally spaced, **on which of the following number lines does point *D* correspond with the fraction $\frac{1}{4}$?**
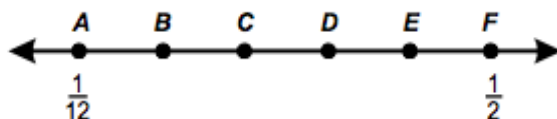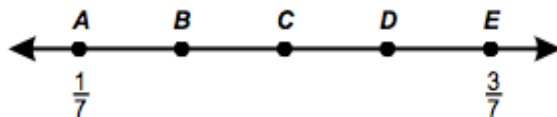
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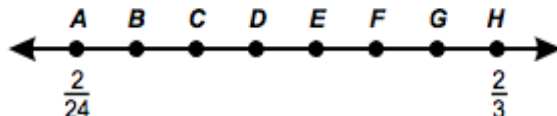
B.

C.

D.

Source: MTEL MS Math practice,
http://www.mtel.nesinc.com/PDFs/MA_
FLD047_PRACTICE_TEST.pdf , Test 47

John, a 4th grader, is given the following story problem to solve.

At the Yummi Bakery, muffins are sold 6 muffins per bag. Mrs. Rust buys three bags of muffins. That is all she buys. How many muffins did Mrs. Rust buy?

John drew the following sketch and wrote "6" as his answer.

Mr. Edwards, John's teacher has seen this type of answer before. What common difficulty is suggested by John's response and has led to his error?

A.   He does not yet understand proportional reasoning.
B.   He erred when making his sketch and relied on that sketch.
C.   He does not understand the meaning of the phrase "per bag."
D.   He does not know his facts; he does not know that 3 × 6 = 18.

Source: Campbell et al.

HLM Models: Model 1

Level-1 Model

$$Posttest_{ij} = \beta_{0j} + r_{ij}$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

HLM Models: Model 2

Level-1 Model

$$Posttest_{ij} = \beta_{0j} + \beta_{1j}*(Pretest_{ij}) + r_{ij}$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + u_{0j}$$
$$\beta_{1j} = \gamma_{10}$$

HLM Models: Model 3

Level-1 Model

$$Posttest_{ij} = \beta_{0j} + \beta_{1j}*(Pretest_{ij}) + r_{ij}$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(Treatment_{j}) + u_{0j}$$
$$\beta_{1j} = \gamma_{10}$$

HLM Models: Model 4

Level-1 Model

$$Posttest_{ij} = \beta_{0j} + \beta_{1j}*(Pretest_{ij}) + r_{ij}$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(Treatment_j) + u_{0j}$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11}*(Treatment_j)$$

HLM Results for LMT: Fixed Effects

	Model 3	Model 4
Model for posttest intercept (β_{0j})		
Intercept (γ_{00})	20.44***	20.43***
Treatment (γ_{01})	0.58	0.58
Model for pretest slope (β_{1j})		
Intercept (γ_{10})	0.76***	076***
Treatment (γ_{11})		0.00

Effect size: Hedges' g = 0.09

HLM Results for MKT-VR: Fixed Effects

	Model 3	Model 4
Model for posttest intercept (β_{0j})		
Intercept (γ_{00})	13.57***	13.56***
Treatment (γ_{01})	0.00	0.00
Model for pretest slope (β_{1j})		
Intercept (γ_{10})	0.61***	0.64***
Treatment (γ_{11})		-0.06

Effect size: Hedges' g = 0

Considerations

- No effect of VAM PD on these measures of teachers' MKT
- Instruments may not be well aligned to the intervention
- Additional measures to analyze:
  - Open Response Exercise (project-developed performance assessment)
  - Qualitative data (notebook responses, interviews)

RQ 2: Self-efficacy

Self-Efficacy Instrument

- Assembled and adapted 19 items from existing instruments:
  - 5 items on participant use of VRs for own problem solving
  - 5 items for teaching students using VRs
    - Lent et al., 1991; Marsh, 1992; Usher & Pajares, 2008
  - 9 items on teaching mathematics to students who are English Learners
    - Wright-Malley & Green, 2015; Tschannen-Moran and Woolfolk Hoy, 2001, 2009; Lucas & Villegas, 2013

Self-Efficacy Instrument (cont'd)

- Likert scale (1-7), strongly disagree to strongly agree
- Appropriate for group-level inferences
- Valid for use by others as a pre/post measure

Self-Efficacy Sample Items

- I am confident I can **create visual representations**, such as double number lines and tape diagrams, to solve ratio and proportional reasoning tasks.

- I am confident I can **help students learn to describe the connections between a visual representation and an algorithmic approach** to solving a ratio and proportional reasoning task.

- I am confident I can effectively **implement strategies** that help ELs get started on mathematics tasks in my class.

HLM Model (Final)

Level-1 Model

$$Posttest_{ij} = \beta_{0j} + \beta_{1j}*(Pretest_{ij}) + r_{ij}$$

Level-2 Model

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(Treatment_j) + u_{0j}$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11}*(Treatment_j)$$

HLM Results for Self-Efficacy-VR: Fixed Effects

	Model 3	Model 4
Model for posttest intercept (β_{0j})		
Intercept (γ_{00})	55.85***	55.77***
Treatment (γ_{01})	6.49***	6.51***
Model for pretest slope (β_{1j})		
Intercept (γ_{10})	0.28***	0.42***
Treatment (γ_{11})		-0.30*

Effect size: Hedges' g = 0.79

Self-Efficacy-VR Results Example

Pretest score at:	Est. posttest self-efficacy-VR score		
	Control	Treatment	Diff
20th percentile	52.6	61.4	8.8
Mean	55.8	62.3	6.5
80th percentile	58.9	63.2	4.3

HLM Results for Self-Efficacy-EL: Fixed Effects

	Model 3	Model 4
Model for posttest intercept (β_{0j})		
Intercept (γ_{00})	44.74***	44.94***
Treatment (γ_{01})	9.48***	9.40***
Model for pretest slope (β_{1j})		
Intercept (γ_{10})	0.58***	0.77***
Treatment (γ_{11})		-0.44**

Effect size: Hedges' g = 1.14

Self-Efficacy-EL Results Example

Pretest score at:	Est. posttest self-efficacy-VR score		
	Control	Treatment	Diff
20th percentile	40.6	52.5	11.9
Mean	44.9	54.3	9.4
80th percentile	49.1	56.1	7.0

Discussion

- Positive impacts of VAM PD on teachers' self-efficacy-VR and self-efficacy-EL

- Significant cross-level interaction effect indicates that impact is greatest for those with lower self-efficacy scores at the start

- Stronger self-efficacy predicts teacher behavior and student achievement (Bandura, 1997; Ross, 2014)

Next Steps

- Complete analyses of ORE to look for additional insight into possible impacts of VAM PD on MKT

- Further analysis of notebook responses and interviews to understand how VAM PD may have had an impact on self-efficacy, and MKT

- Further exploration and dissemination of most useful findings for the field

Questions and Suggestions

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