Using the Rasch Model to Develop a Culturally Responsive Measure of Student Math Engagement

Student Engagement

- Student engagement is a multifaceted concept. It is most commonly defined in terms of:
  - **Behavioral engagement:** Observable behaviors such as involvement in academic activities, positive conduct, and the absence of disruptive behavior
  - **Cognitive engagement:** Cognitive strategies that support learning such as self-regulated learning and persistence
  - **Emotional engagement:** Positive emotional reactions such as valuing and enjoying learning, having interest in the content, and feeling positively toward peers and adults
  - **Social engagement:** Quality social interactions with peers and adults that facilitate learning

- As we aim to improve student math engagement, relevant and aligned measures are necessary to monitor progress toward goals.

Bingham & Okagaki, 2012; Stinson, 2004; Martin et al., 2015; Wang et al., 2016;

How Can We Better Promote Math Engagement for Black and Latino Students?

- Several factors promote math engagement for Black and Latino students:
  - Positive student-teacher relationships
  - Sense of belonging
  - Culturally responsive practices
  - Positive role models
  - Perceived peer and adult support
  - Addressing negative stereotypes
  - Perceived math utility

EquitableMath.org, 2021; Gutierrez & Irving, 2012

The Role of Measurement in Supporting Student Engagement

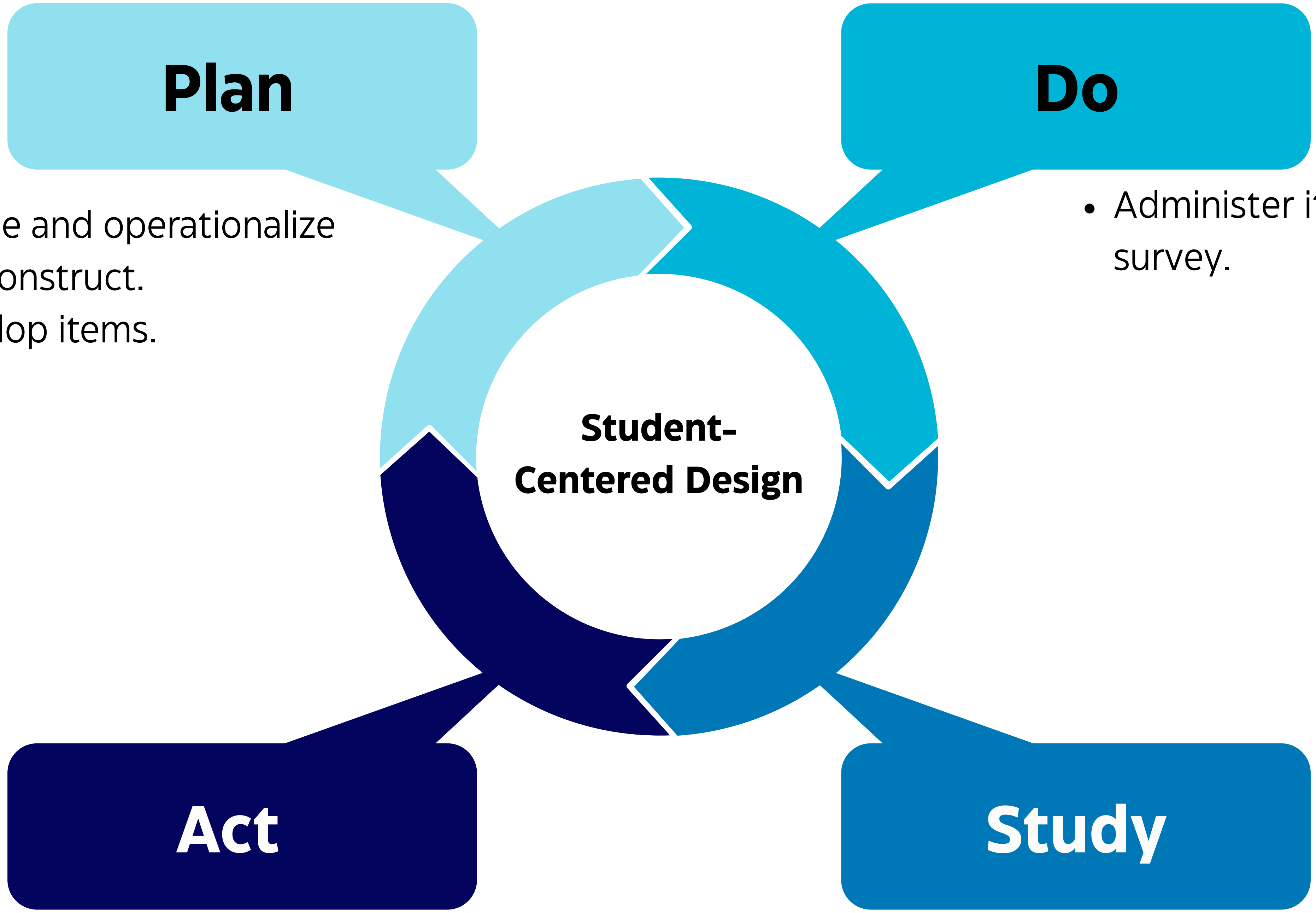
- Despite many initiatives focused on promoting engagement, especially engagement of marginalized youth, few measures are designed in a way that centers Black and Latino student math engagement experiences.

Project Goal

To develop a culturally relevant and sustaining measure of students’ math engagement in Bloomington, Minnesota, centering the experiences of Black and Latino students

Our Approach to Measurement Development

- We relied on a continuous improvement, mixed methods approach that was grounded in critical participatory action research (cPAR) principles.



- Define and operationalize the construct.
- Develop items.

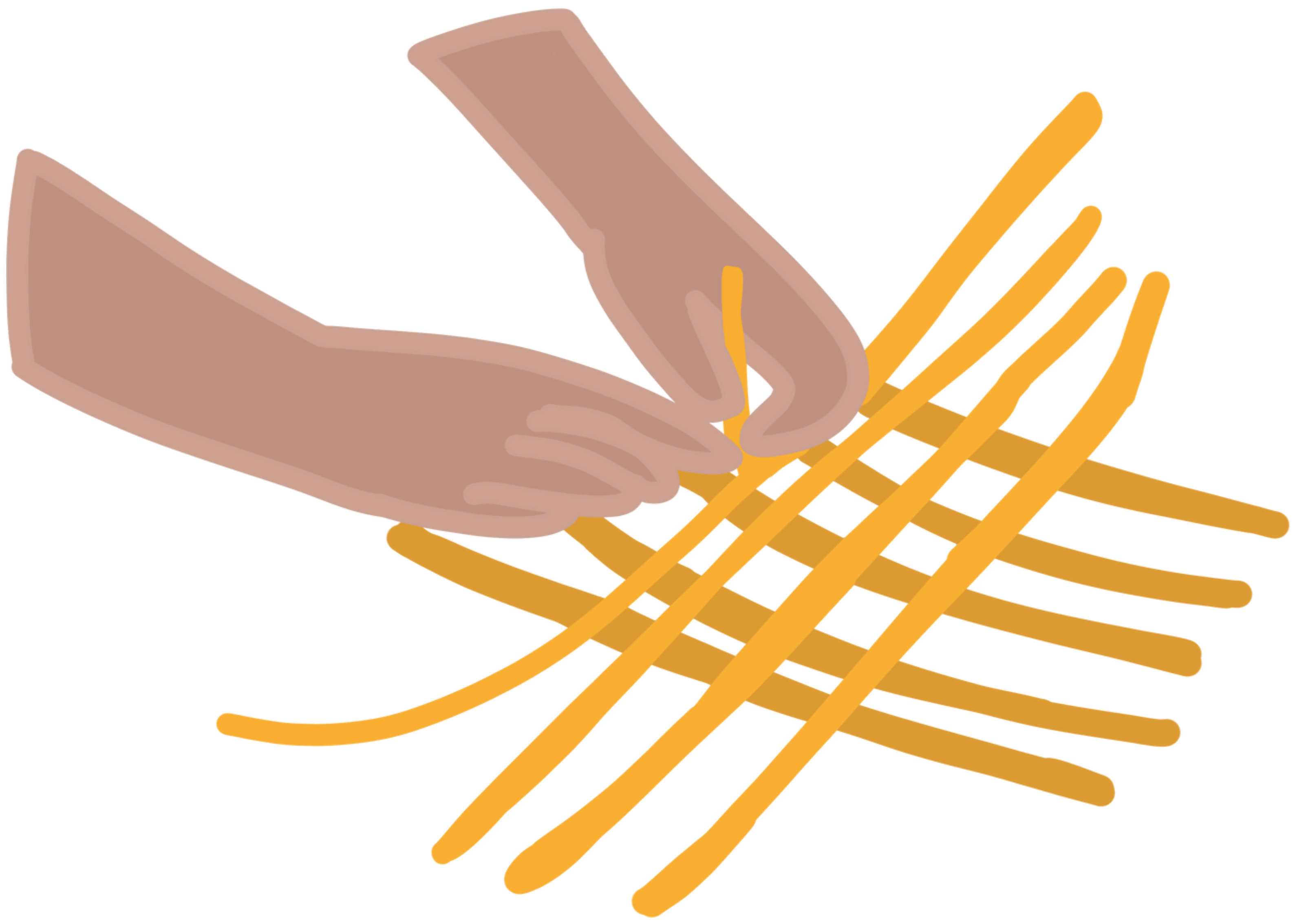
- Administer items in a survey.

- Reliability and validity testing.

- Item refinement.

Langley et al., 2009; Price et al., n.d.

Mixed-Methods Design



Quantitative Methods
• Descriptive Analyses • Exploratory and Confirmatory Factor Analyses • Rasch Analyses
Qualitative Methods
• Staff and student interviews. • Student focus groups.

Application of the Rasch Model

- Rasch analysis is an approach that aligns with item response theory.
  - It assumes that measurement error varies across levels of the latent construct (e.g., engagement).
- Item and person locations are placed on the same metric for comparisons. For Likert scale items:

$$\log\left(\frac{p_{nij}}{p_{ni(j-1)}}\right) = B_n - D_i - F_j$$

B_n is the location of person *n* on the latent construct, D_i is the average item location of item *i*, and F_j are the thresholds for the *j* categories in the Likert scale.

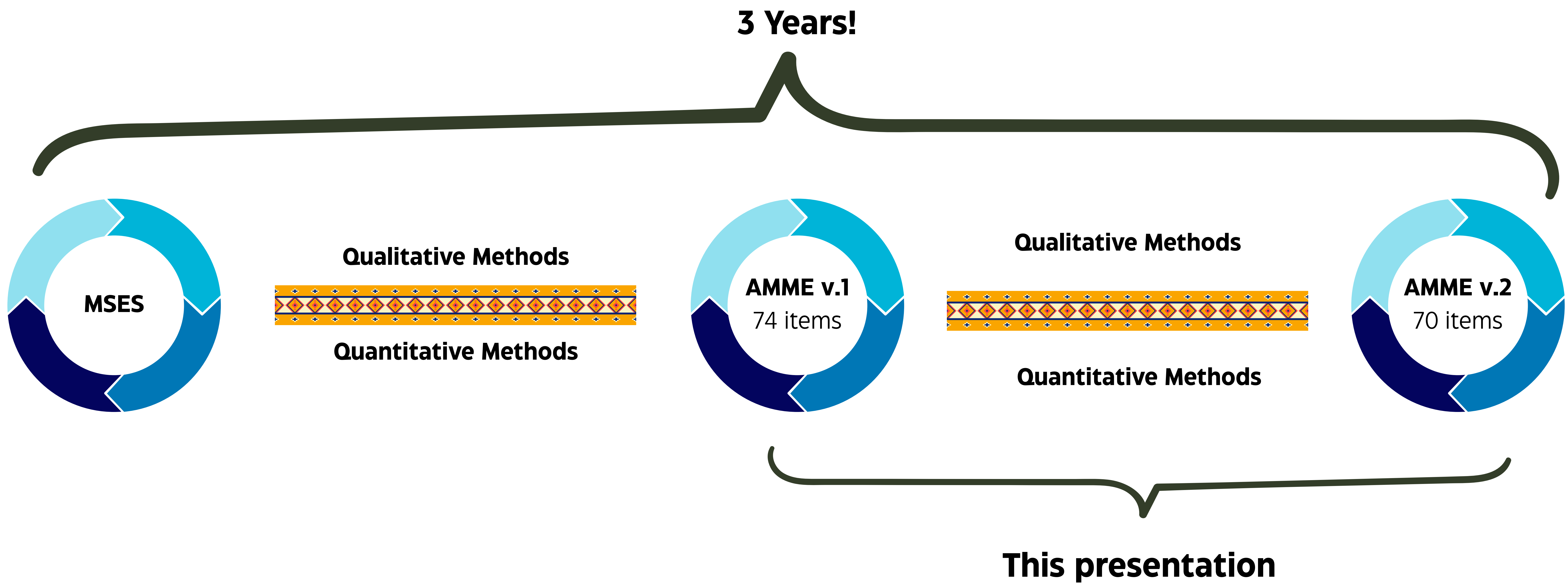
- This approach has been shown to be useful in helping education practitioners think critically about person and item location along the latent construct.

(Bond & Fox, 2015; Davidson et al., 2018)

Measurement Development Research Questions

Developmental Research Question	Statistical Parameter(s)
1. Does our measure have items (sources of information) across all levels of the latent construct? a. How well do item locations align with student locations?	Person location/ability (θ) Item location/difficulty (*b*)
2. Do some items function differently for certain groups of students?	Differential Item Functioning (DIF)

Focus of This Presentation



Survey Administration

- Surveys were administered each spring in 3 middle schools and 2 high schools to students in grades 6 to12.

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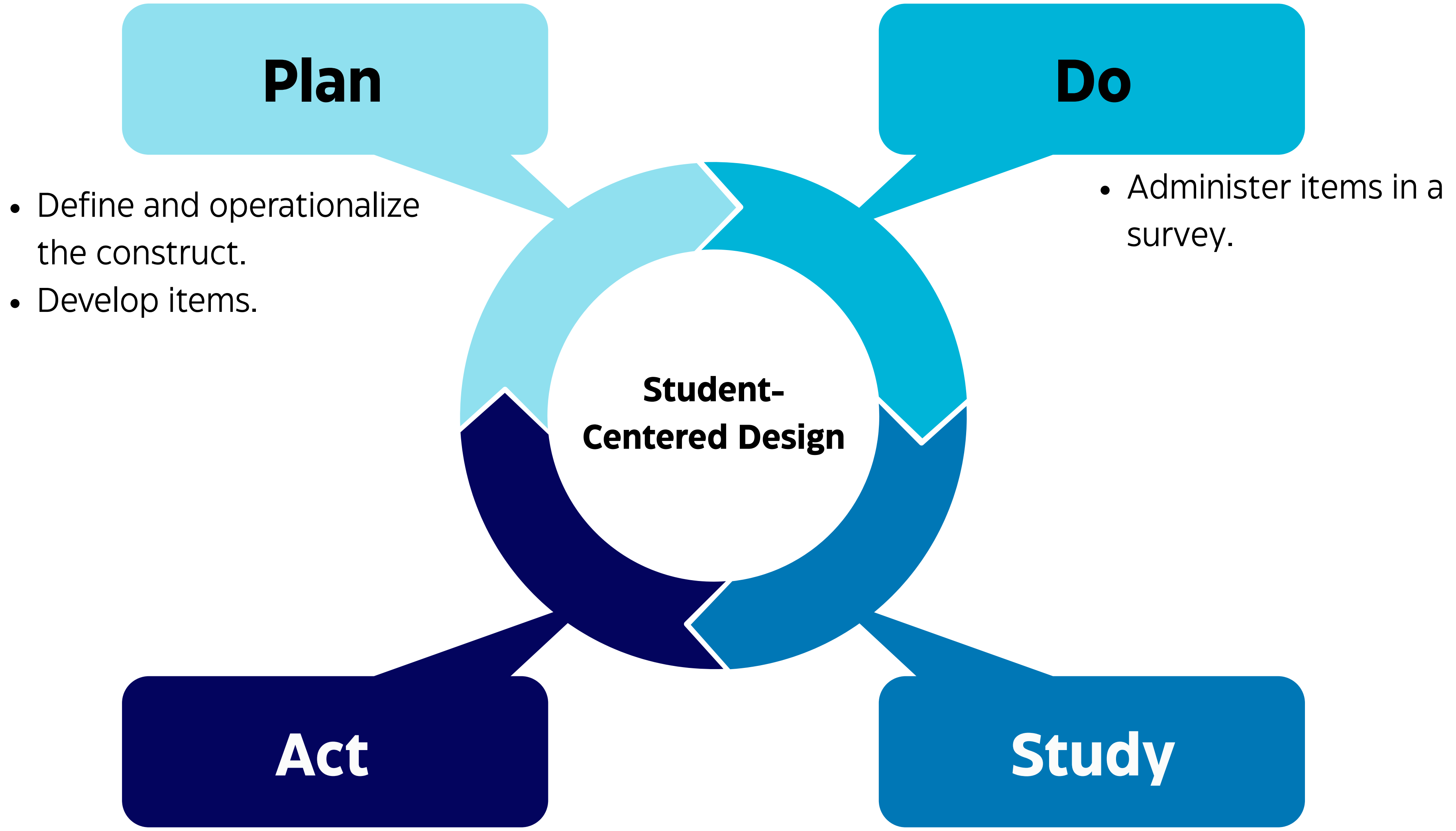
- **Year Three (2025):** Administered the 70-item Adapted Measure of Math Engagement (version 2) to measure 10 domains of engagement using planned missingness.
  - 2,727 students (20% Black, 25% Hispanic, 56% Other).

Student Definitions of Math Engagement

Students defined math engagement in terms of 6 dimensions:

- Visible engagement
- Classroom culture
- Feelings toward math
- Relevance of math
- Support outside of the classroom
- External factors

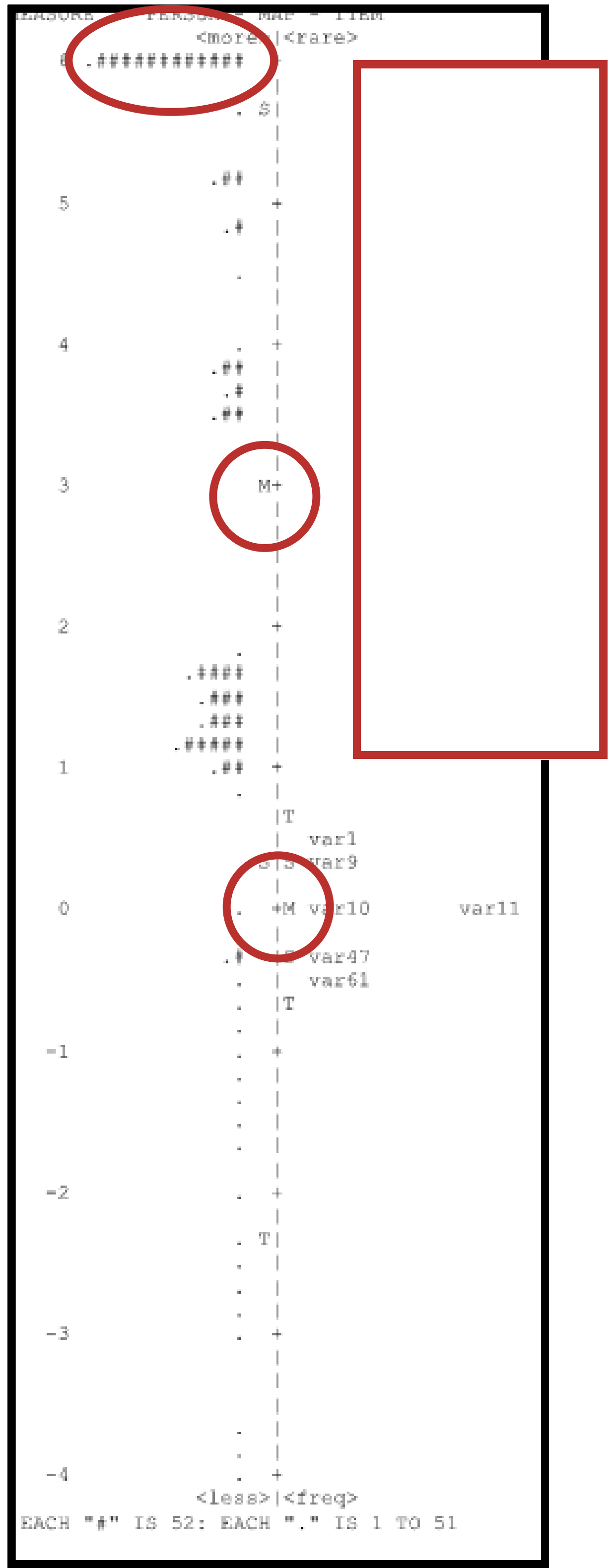


Year Two (2024) Findings

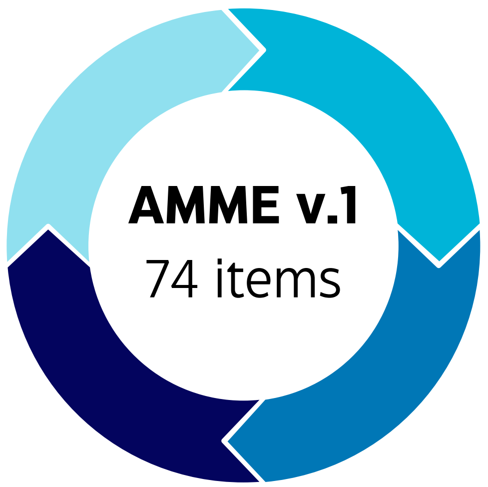
- Factor Analyses: An 8-factor solution emerged
  - CFI = 0.99; RMSEA = 0.04 [CI90%: 0.03, 0.04]; SRMR = 0.06
- Item-Person Placement
- Differential Item Functioning

Feelings Toward Math

Strongly Agree

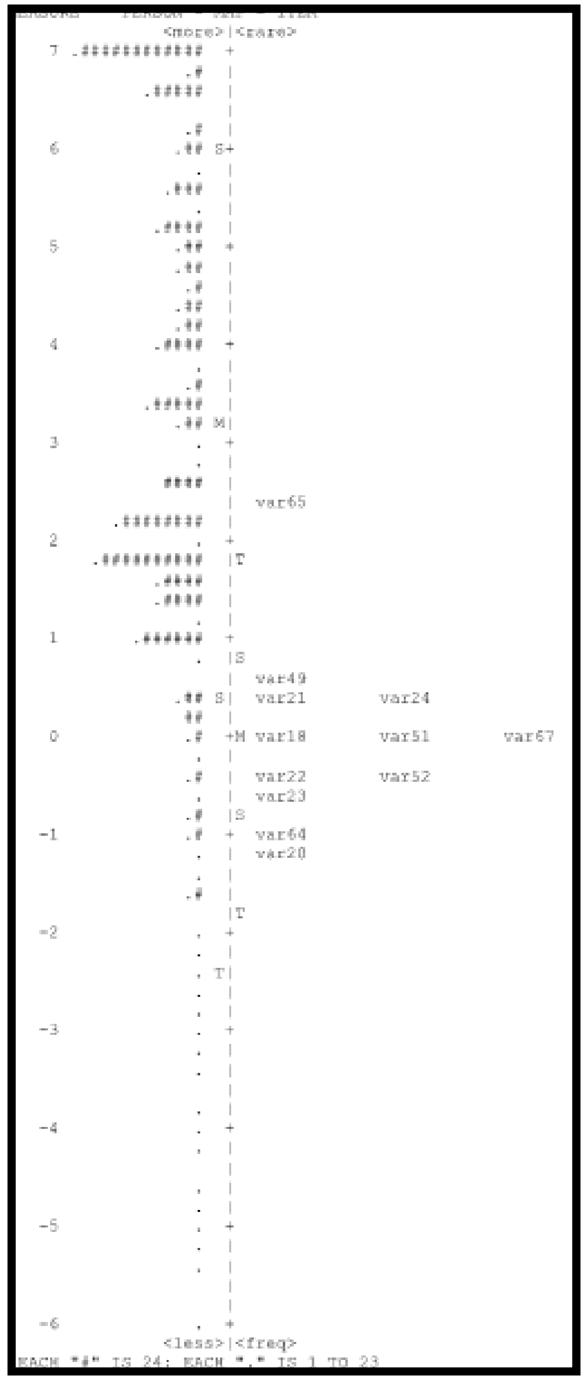


Strongly Disagree

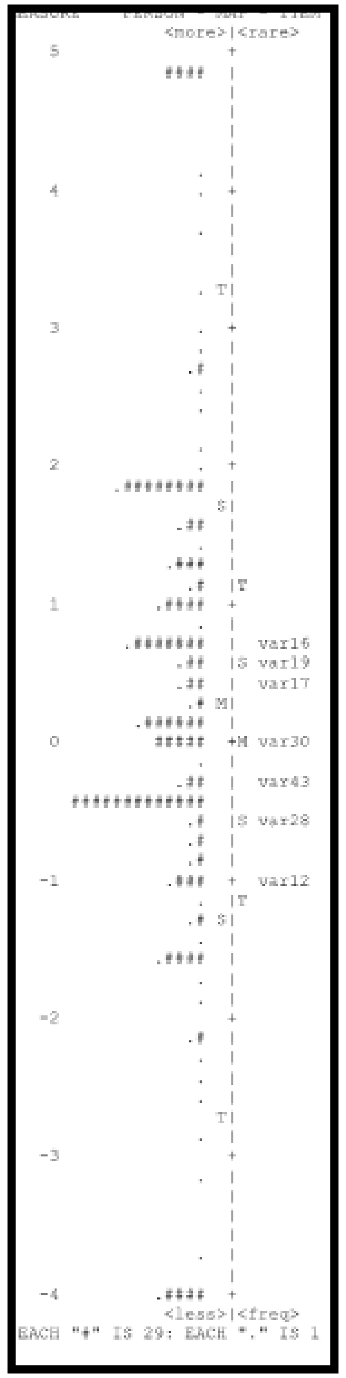


Item-Person Placement

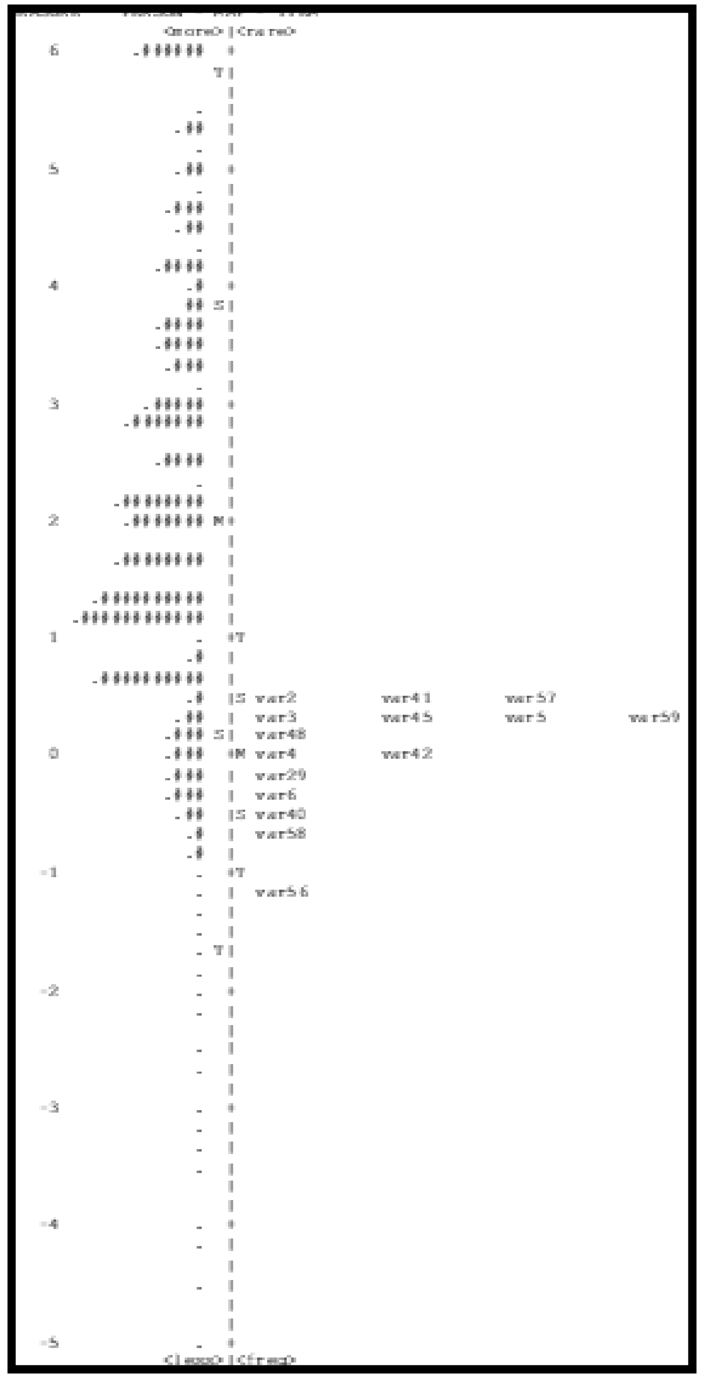
Teacher-Student Relationships



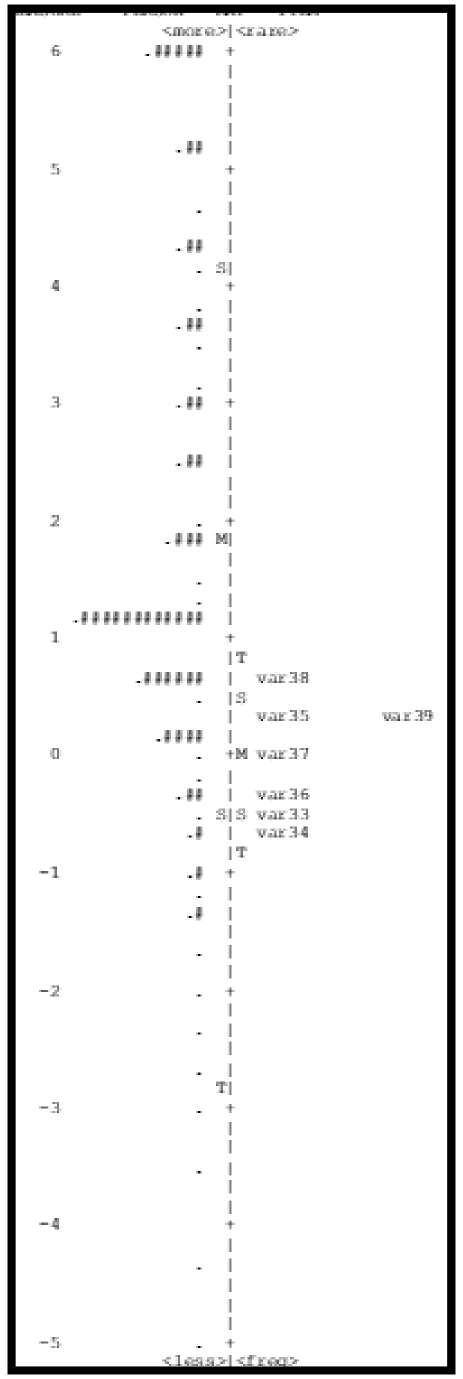
Barriers to Learning



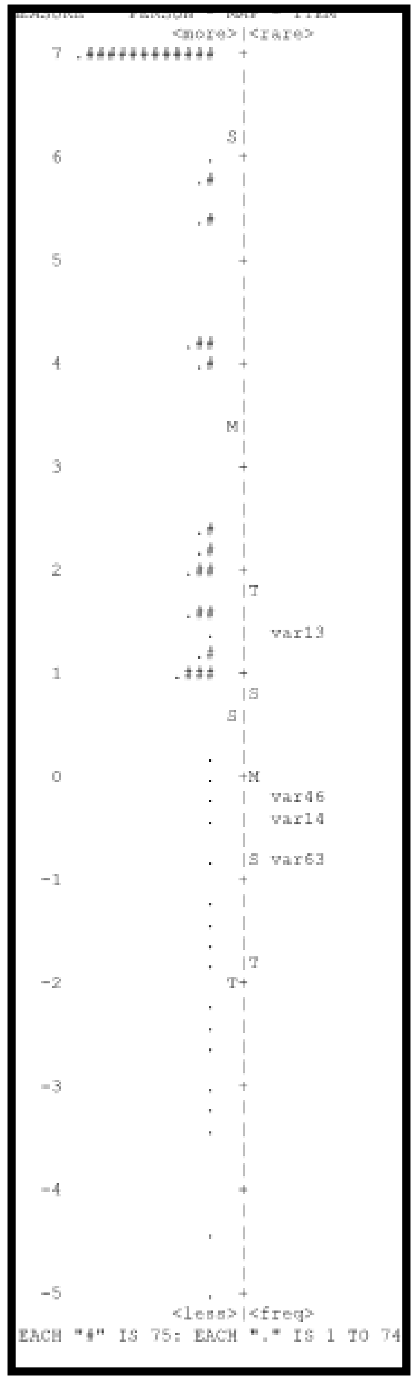
In-Class Engagement



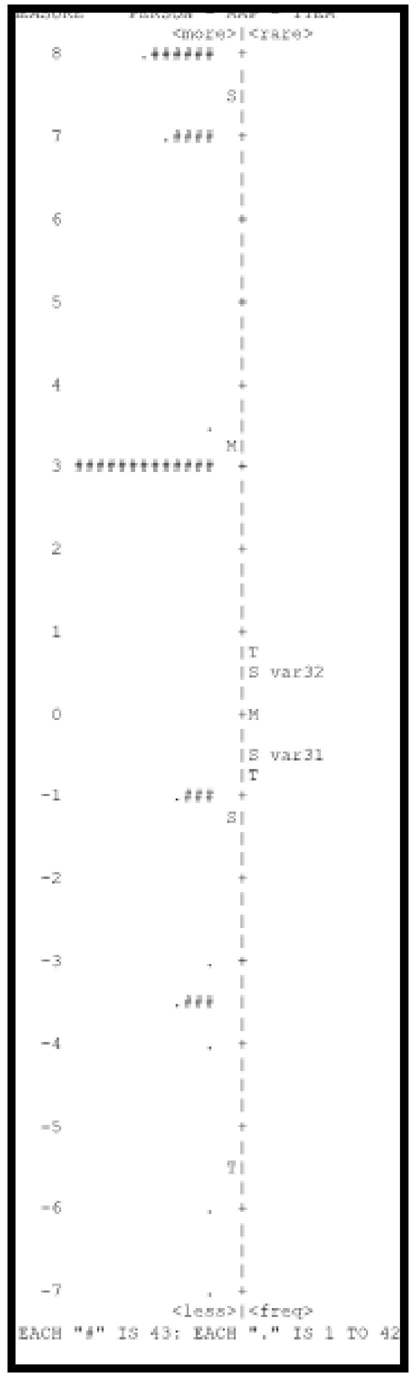
Social Support



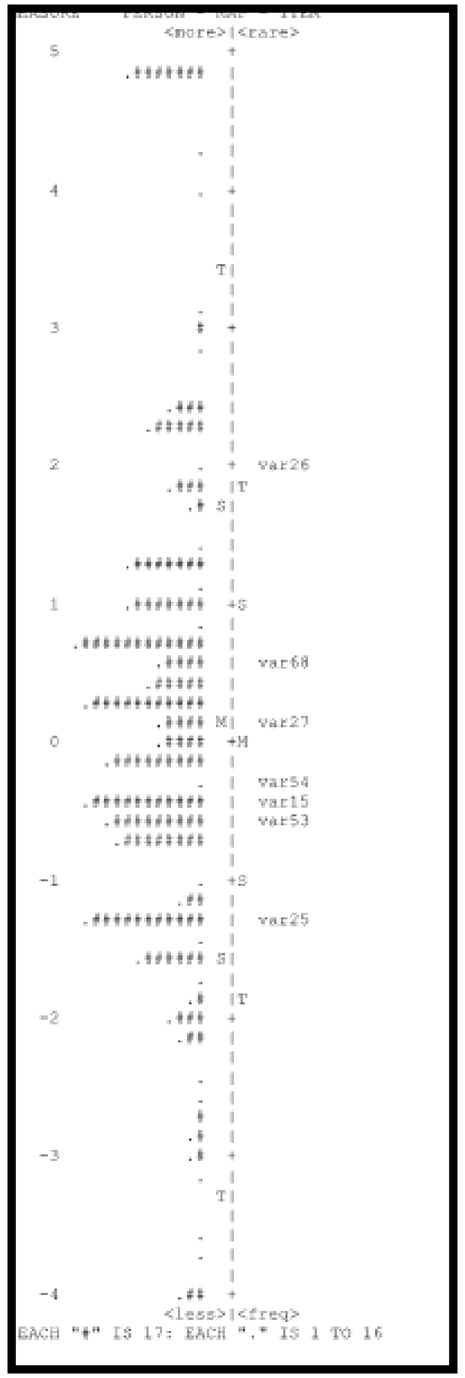
Math Understanding



Math Identity



Math Utility



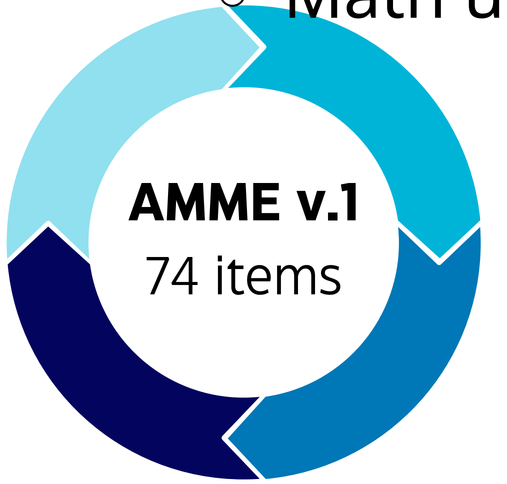
Year Two (2024) Findings

- Factor Analyses: An 8-factor solution emerged
  - CFI = 0.99; RMSEA = 0.04 [CI90%: 0.03, 0.04]; SRMR = 0.06
- Item-Person Placement
- Differential Item Functioning
  - Feelings toward Math: 1 of 6 items
  - Teacher-Student Relationships: 1 of 12 items
  - Barriers to Learning: 1 of 7 items
  - In-Class Engagement: 4 of 15 items
  - Social Support: 1 of 7 items
  - Math Understanding: 2 of 4 items
  - Math utility: 3 of 7 items

General DIF Patterns

Black and Latino students were less likely to report using external resources, like afterschool programs, study sheets.

Example: Black and Latino were less likely than Other to agree to, "**I attend an afterschool program where I get help with math**," ($\Delta bs > |.46|$)



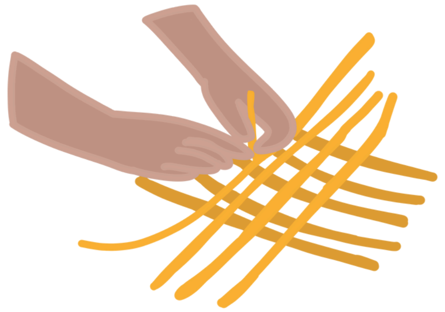
Year 2 Implications for Measurement

- The 8-factor structure somewhat aligned to student definitions.
  - **Feelings Toward Math**
  - **Teacher-Student Relationships**
  - **Barriers to Learning**
  - **In-Class Engagement**
  - **Social Support**
  - **Understands Math**
  - **Math Identity**
  - **Math Utility**
- Items do not measure higher levels of math engagement across domains.
- Students tend to "max out" the scale.
- Patterns in DIF suggest students may have different types of experiences with math resources.

Next Steps

- Understand what higher levels of engagement look like for students.
- Incorporate relevant theories related to math learning and culturally relevant and sustaining education.
- Refine AMME v.1.

Informing Qualitative Investigations



"Me and my friend, we always help each other … we ask our teacher to sit next to each other because we know how to help each other in the ways that both of us know… So it's really fun and you learn faster with them."
– female, Hispanic Ecuadorian, Grade 6

Student Focus Groups

- Asked students to give examples of high engagement

My classmates keep me motivated in math class.

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Consultations with Advisory Board

- Reviewed related theoretical framework.

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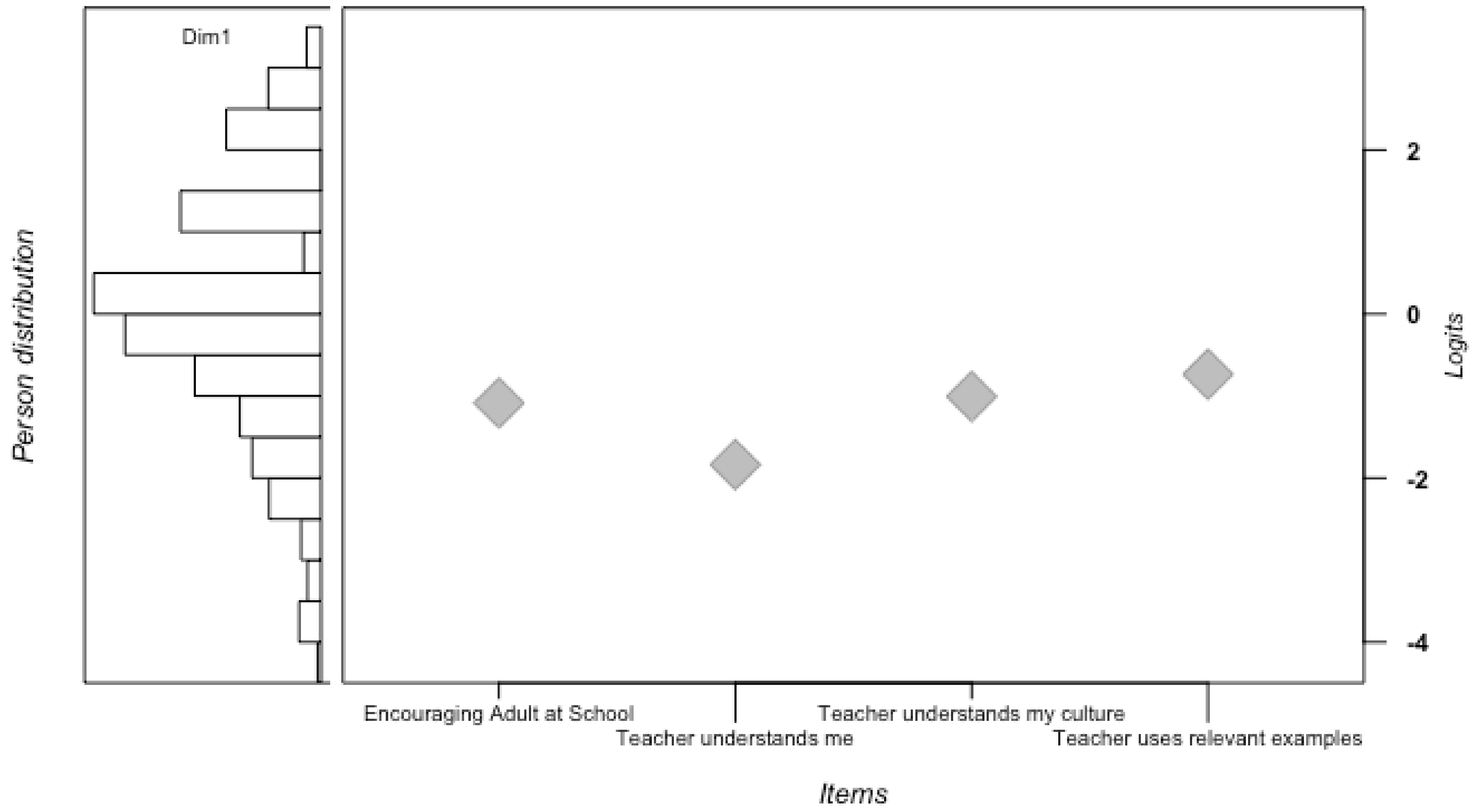
Dimensions were renamed, and four new dimensions were identified:

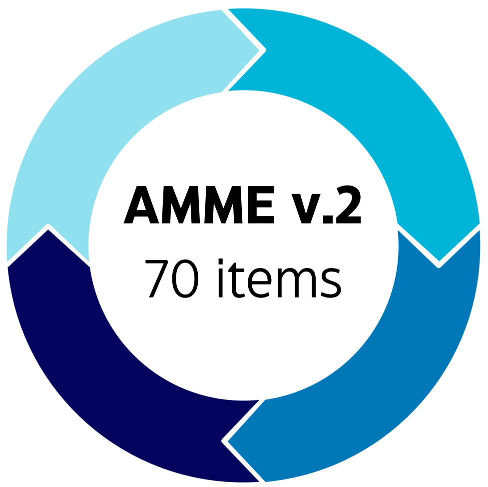
- Classroom behavior
- Classroom climate
- Feelings toward math
- Math importance
- Community support
- Math resources
- NEW: Math mastery
- NEW: Effective Instruction
- NEW: Student-Teacher relationships
- NEW: Math identity

Year 3 Findings

- Factor Analyses: An 8-factor solution emerged
  - CFI = .964; RMSEA = 0.046 [CI90%: 0.043, 0.048]; SRMR = 0.076
- Item-Person Placement
- Differential Item Functioning

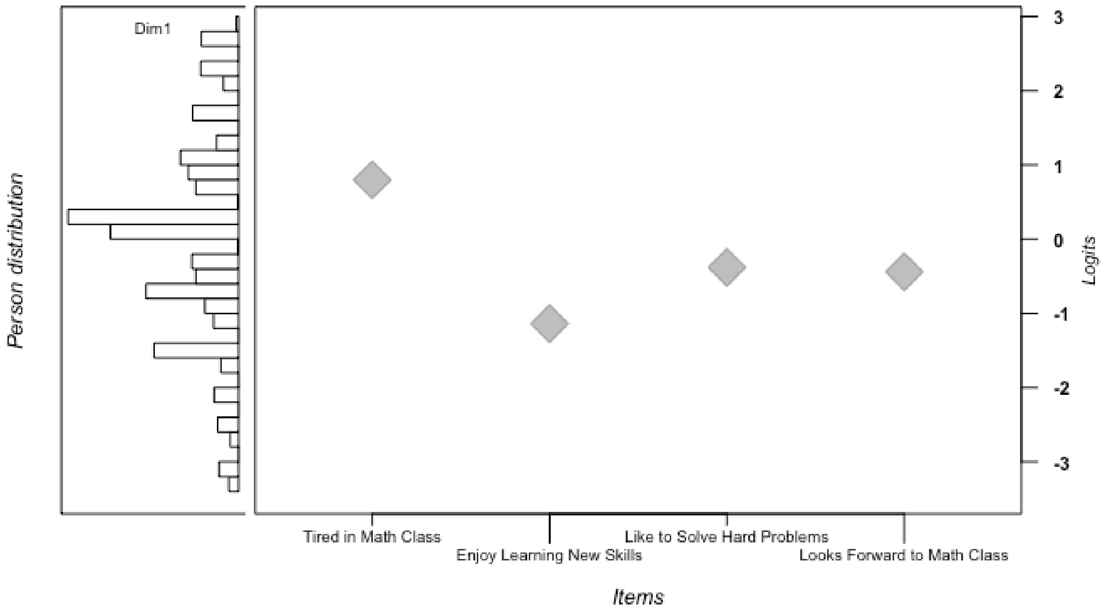
Personalized Math Teaching



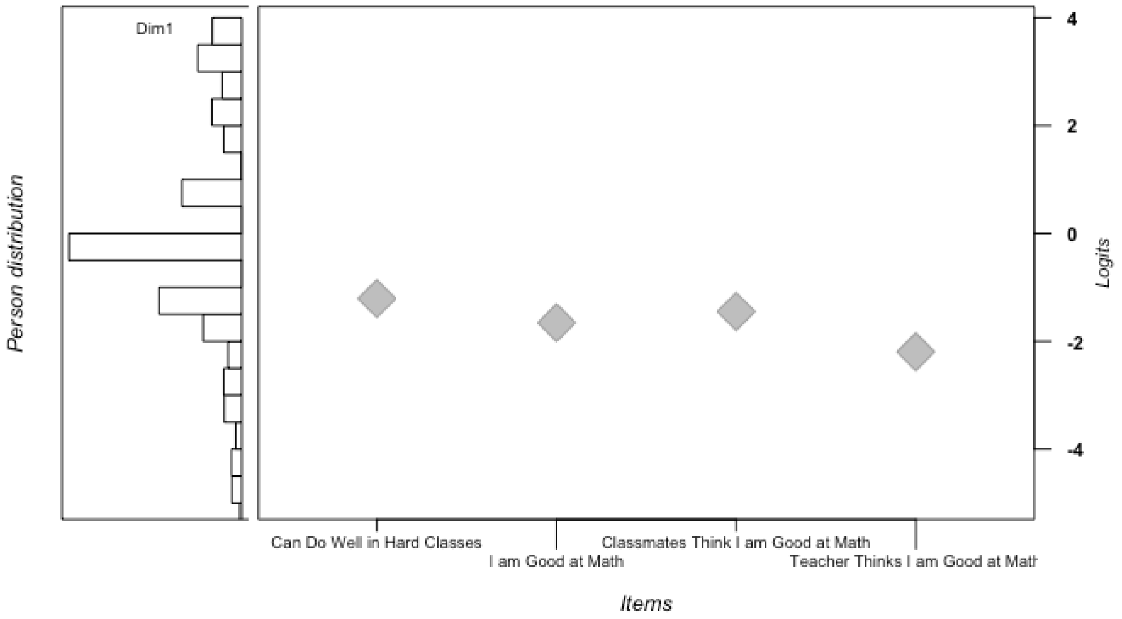


Item-Person Placement

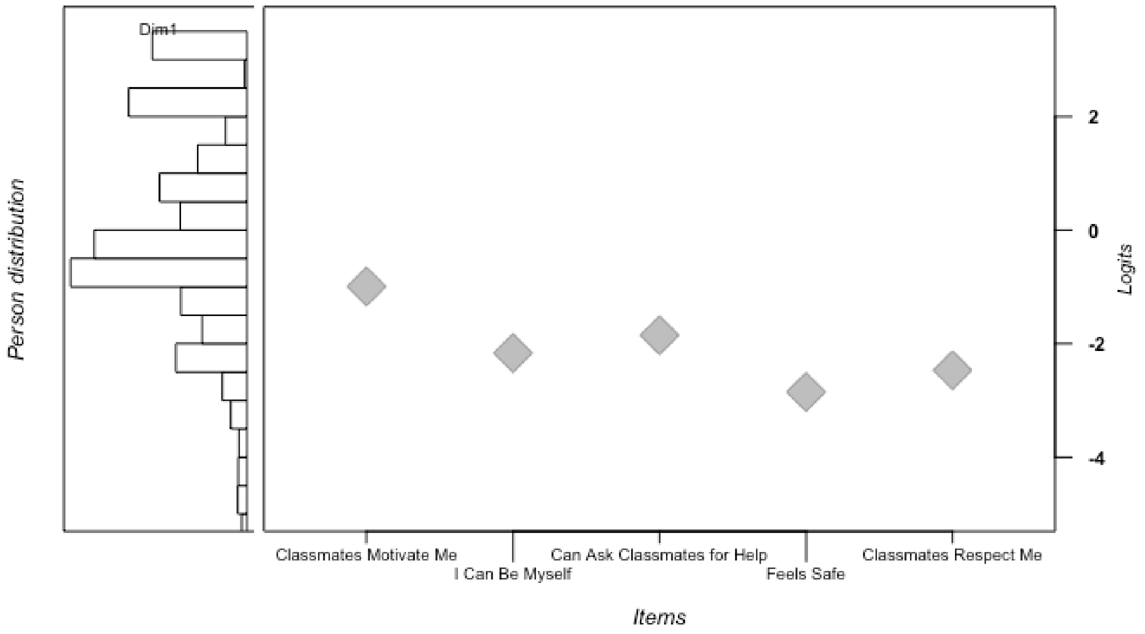
Math Enthusiasm



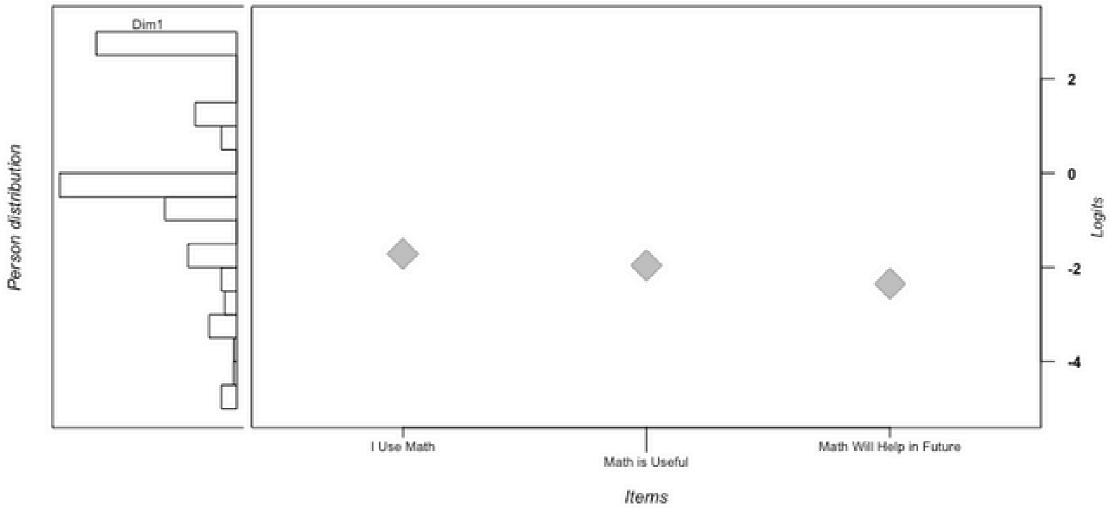
Math Identity



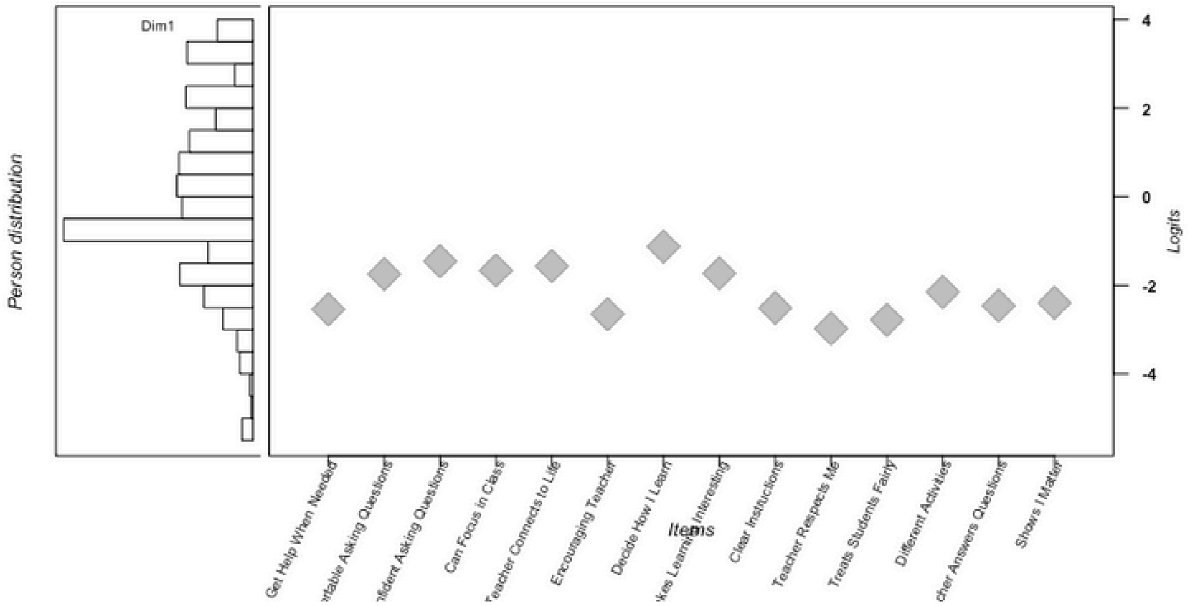
Belonging in Math Class



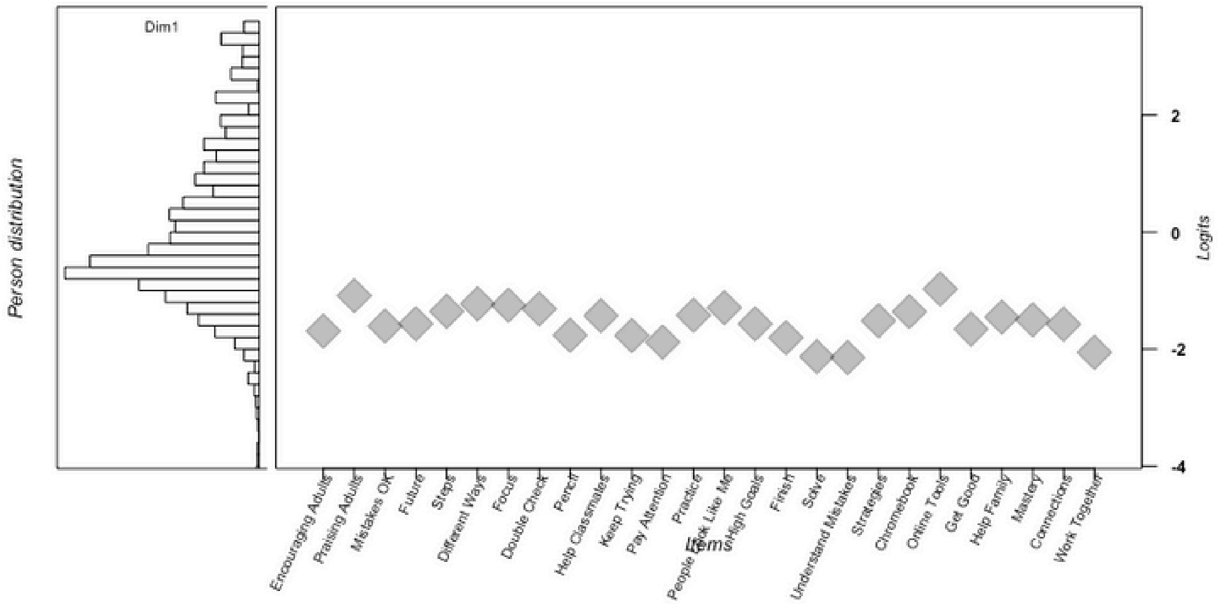
Math Usefulness



Supportive Math Teaching

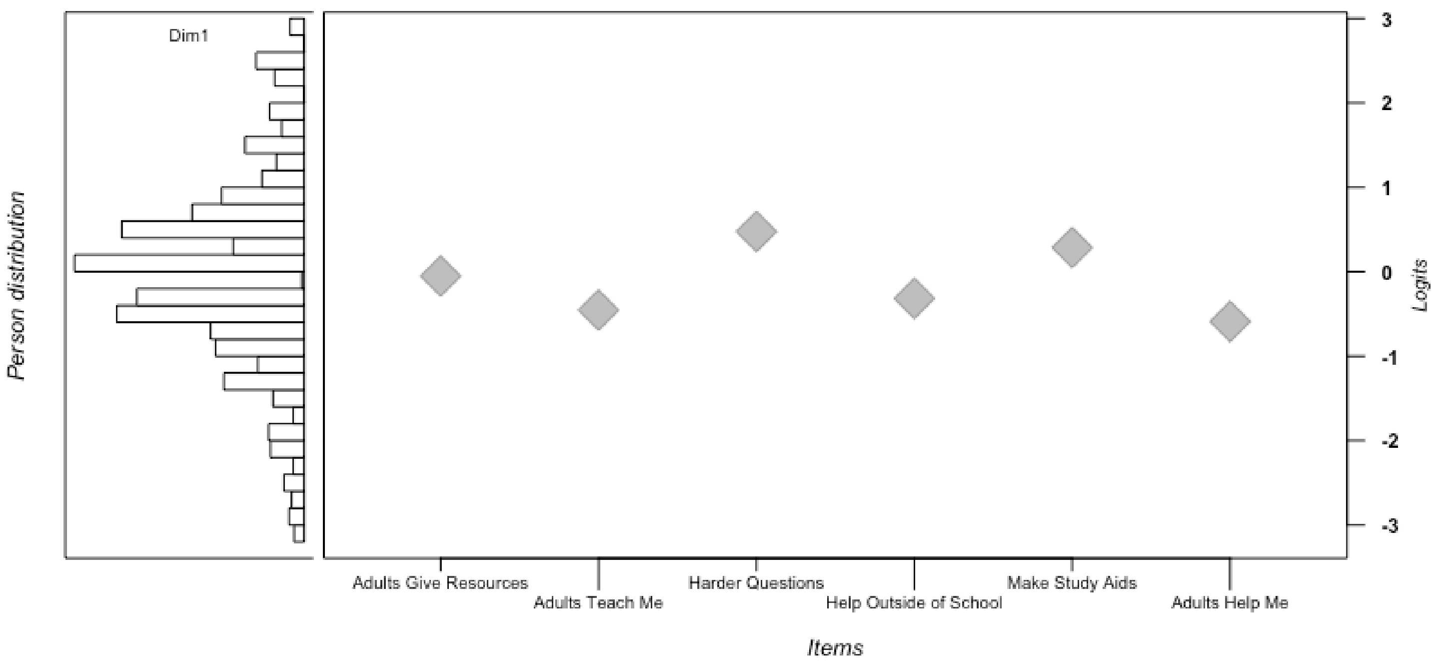


Math Learning Behaviors



Item-Person Placement

Community Resources for Learning Math



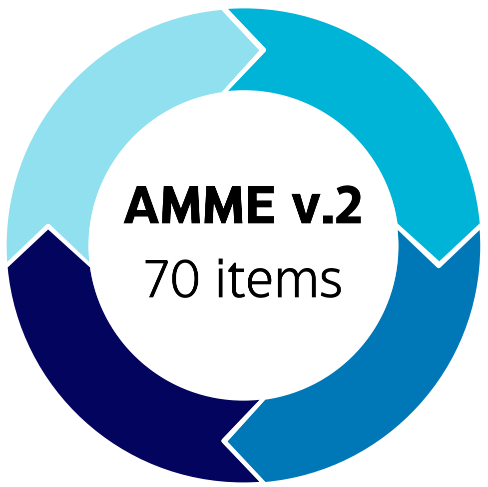
Year 3 Findings

- Factor Analyses: An 8-factor solution emerged
  - CFI = .964; RMSEA = 0.046 [CI90%: 0.043, 0.048]; SRMR = 0.076
- Item-Person Placement
- Differential Item Functioning
  - Humanizing Math: 1 of 4 items
  - Belonging in Math: 1 of 5 items
  - Quality Teaching: 2 of 14 items
  - Math Learning Behaviors: 11 of 26 items
  - Community Resources: 2 of 6 items

General DIF Patterns

Some items reflected math behaviors (e.g., double checking answers) while others reflected potential cultural differences (e.g., math to help family).

Example: Black students were less likely to agree than Other students to, "**Adults outside school give me math resources...**," ($\Delta bs > |.43|$)



Year 3 Implications for Measurement

- We further refined how we defined and operationalized student math engagement
    - **Humanizing Math**
    - **Growth Mindset**
    - **Math Identity**
    - **Belonging in Math**
    - **Math Utility**
    - **Quality Teaching**
    - **Math Learning Behaviors**
    - **Community Resources**
- Ceiling effect was reduced but still experienced difficulty designing “difficult” items
- Some item locations varied as a function of group membership
    - Suggests that items may reflect different experiences independent of the constructs

Next Steps

- Identify the final set of items based on qualitative and quantitative information.
- Examine reliability and validity evidence of the final AMME.

Upcoming Presentation

Conclusions

- Preliminary evidence for **face and construct validity** of a student-centered measure of math engagement
- Demonstrated process for **integrating Rasch analysis** into a mixed methods **cPAR** approach to measurement design
    - Facilitates learning of measurement design in informal education settings
- Measuring **high levels of engagement** continued to be a challenge
    - Echoes other literature on measuring students' self-reported "non-academic" competencies or mindsets
- Future research can expand this work by investigating
    - **Reliability and validity** of the measure to inform practices and change over time
    - **Transitional periods** (freshmen in college) may lend insights into higher levels of math engagement
    - Identifying methods to make **self-report items of "non-academic" skills** more difficult to agree to

The Adapted Measure of Math Engagement Research Group includes six students (Antonio Chavira, Brianna Espy, Ryan Ombongi, Serrah Ssemukutu, Salma Ahmed, and Diamond Tony-Uduhirinwa), five teachers (Nathan W. Earley, Karina Mazurek, Kathleen Morgan, Karla Rokke, and Ashly Tritch), and five researchers (Marisa Crowder, Samantha E. Holquist, Diane (Ta-Yang) Hsieh, Claire Kelley, and Mark Vincent B. Yu). Researchers Alyssa Scott, Olivia Reyes, and Avalloy McCarthy also extensively contributed to this work. Bloomington Public School District leaders Betsy Hawes, Marcie Coval, Julio Caesar, and Rik Lamm provided support to this work. Jennifer Widstrand served as the project manager.

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