Building Mathematical Identity After School: Results of a Cluster-Randomized Trial

Andrea D. Beesley, SRI International
Cheri Fancsali, Research Alliance for New York City Schools
Michaela Gulemetova, IMPAQ International

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Background

We are conducting a cluster-randomized trial of the After-School Math Plus curriculum (ASM+), which is intended to build mathematical identity among students in groups under-represented in STEM (women, persons with disabilities, African-Americans, and Latino/as; NSF, 2011). Over half of secondary students do not feel they need math outside of school, and they think that liking math is unpopular (Markow & Moore, 2001). If these students continue along this path, they will not be eligible for at least 75% of the jobs of the future (Fleming, 2012). Elementary-level experiences are thus important in attracting students to STEM before they disengage.

Mathematical identity refers to the ways that students think about themselves in relation to mathematics and the extent to which they have developed a commitment to, and have come to see value in, mathematics (Cobb, Gresalfi, & Hodge, 2009). Therefore, it encompasses persistence and interest in mathematics and motivation to learn mathematics. A strong mathematical identity is thought to be key to doing well and persisting in math. Out-of-school time experiences afford opportunities to build positive math identity in students because pressure to perform for grades and scores is absent. In addition, after-school programs provide opportunities to increase students' access to mathematical content and discourse, and build students' identity as knowers/doers of mathematics (Cobb & Gresalfi, 2006). With some exceptions (Berry, 2008; Nasir, 2002), few previous studies examine identity motivation, and fewer yet study out-of-school experiences and identity motivation. This study helps fill that gap, responding to demand that after-school programs demonstrate social-emotional and academic outcomes.

Research Questions

1) What is the effect of ASM+ on students' math identity and achievement in math?
2) What is the relationship between math achievement and math engagement, interest, and identity?
3) To what extent do after-school educators possess a math identity, and does it increase as a result of participating in this project?
4) What is the relationship between after-school educators' math identity and students' identity?

Setting

We implemented the study in 45 after-school programs in NYC and South Carolina that serve students in grades 4–5.

Intervention

ASM+ is designed to provide engaging, inquiry-based math activities that enhance the key influencers of math identity (see Exhibit 1). Students in the study were exposed to 4 themes:

ArtMath, Jump Rope Math, Built Environment, and MusicMath, each taking up to 12 weeks to implement. Educators attended one day of training for each theme and received follow-up support.

Research Design

After-school programs were randomly assigned to implement the full ASM+ curriculum or a control version without the activities hypothesized to foster math identity, in 2016-17 and 2017-18.

Data Collection

Data sources:

Student survey. This pre/post survey measured students' math identity (see Exhibit 2) and gathered data on students' reactions to the ASM+ curriculum activities. It was administered at baseline and after each theme.

Training feedback form. This form collected after-school educators' immediate impressions after training.

Educator survey. This survey captured which activities were completed, challenges and supports for the implementation, and the perceived effect of ASM+ on students. It also measures educator's math identity. It was administered after each theme.

Observation protocol. This protocol assessed the extent to which activities engage students, build skills, and provide meaningful opportunities to foster math identity. We conducted observations in 7 treatment and 5 control sites in 2017-18.

Educator interview protocol. Following all the observations, we interviewed educators about program fidelity of implementation and their perceptions of influence on student math identity. We also asked about educators' own math identity.

Achievement. We gathered pre- and post-program math achievement test scores (2016-18) for students in the study.

Analysis

The impact analyses used a 2-level mixed model for each theme (students nested in programs) as well as longitudinal growth curve models (time nested in students), controlling for student-level characteristics and program covariates. Implementation analyses score the degree to which sites participated in the training and completed all of the curriculum activities, by theme.

Findings

Theme 1 was considered a pilot for the study. Findings for Theme 2 are included here. All impact and implementation analyses for all four themes will be completed by SREE 2019, including those relying upon 2018 achievement data, which are not yet available.

Implementation fidelity was weak. Treatment and control sites completed math activities at similar rates, but treatment sites often did not complete the additional identity-supportive activities, such as making literacy connections, discussing math role models, and holding a culminating event. The most commonly requested additional supports were implementation materials, additional training, and additional coaching from the trainers.

As is common in after-school environments, **students frequently left, joined, or rejoined the program.** Some sites ceased operation due to funding problems (e.g., Beesley, 2018). In Theme 2, 27/44 randomized sites implemented the intervention (38.6 percent overall and 13.6 percent differential site-level attrition). In those sites, 649/858 students completed end-of-theme surveys (24.4 percent overall and 3.4 percent differential student-level attrition). While overall power was acceptable, attrition levels raise potential bias concerns. Baseline equivalence analyses demonstrated no site-level statistically significant differences between treatment and control site demographics, but some differences in student-level variables, including grade, race/ethnicity, and baseline math identity.

Exhibit 3 presents the Theme 2 student impact results. While most effects are positive, magnitudes are small and none are statistically significant. There were some significant effects on educator outcomes (self-efficacy for math and sense of math community) for one theme (Exhibit 4).

Conclusions

This paper will present final results from an experimental study of an after-school program focused on mathematical identity. Preliminary analyses indicate no impact on student outcomes and some impact on educator outcomes, as well as substantial challenges to implementation fidelity. Additional analyses will test the program's theory of action, including the extent to which educators' math identity is related to student math identity and the relationship between student math identity and achievement. This study addresses a gap in research about math identity, but also exemplifies the tension between demands for rigorous evidence and the complex context of after-school; findings will have research and practice implications.

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Exhibit 1: Revised Theory of Action

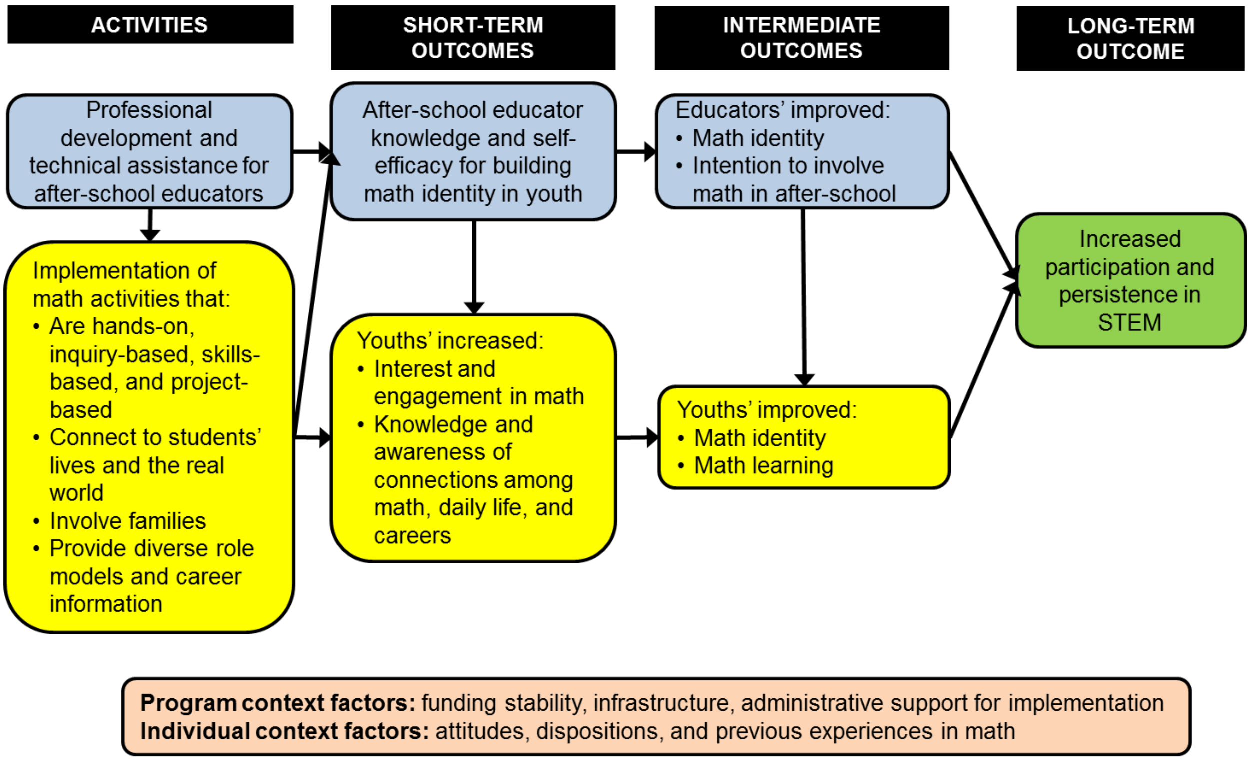

Exhibit 2. Student Math Identity Survey – Subscales, Sources, and Sample Items

Subscale	Source	Sample Item
Math usefulness	Modified Fennema-Sherman Math Attitude Scale - Usefulness (Mulhern & Rae, 1998)	Math is a worthwhile, necessary subject.
Self-perception of math ability	Math and Me (Adelson & McCoach, 2011)	I am really good at math.
Math enjoyment		Math is fun.
Member of math community	Researcher-developed	People like me do math.
Future math plans	Researcher-developed	I plan to use math in my future career.

Exhibit 3. Theme 2 Student Impact Results

Outcome	N	Unadj. Treatment Mean	Unadj. Control Mean	Treatment coeff	S.E.	Effect size	p-value
Math usefulness scale	486	3.75	3.73	-0.125	0.116	0.03	0.283
Math ability scale	486	3.70	3.68	-0.19	0.116	0.02	0.102
Math enjoyment scale	484	3.61	3.53	-0.027	0.178	0.08	0.880
Sense of math community	486	3.78	3.70	-0.068	0.114	0.10	0.550
Math future plans	485	3.45	3.51	-0.117	0.130	-0.06	0.368
Agree Theme 2 was fun	461	3.85	3.69	0.283	0.232	0.11	0.223
Agree Theme 2 was hard	461	2.58	2.34	0.133	0.186	0.16	0.473
Agree Theme 2 was boring	458	2.59	2.72	-0.206	0.210	-0.09	0.326
Like more activities	455	3.48	3.33	0.198	0.262	0.10	0.451
Total attendance rate	474	0.69	0.78	-0.056	0.109	-0.32	0.605
Total ASM attendance rate	474	0.87	0.85	0.040	0.065	0.10	0.538

Exhibit 4. Theme 1 and 2 Teacher Impact Results

	Control		Treatment		
Outcome	Mean	N	Mean	N	P-Value
Usefulness after ArtMath	4.42	30	4.5	25	0.61
Ability after ArtMath	3.89	30	3.72	25	0.45
Enjoyment after ArtMath	3.83	30	3.53	25	0.19
Community after ArtMath	4.12	30	4.08	25	0.82
Efficacy after ArtMath	3.78	30	3.81	25	0.86
Usefulness after Built Environment	4.13	32	4.49	27	**0.01**
Ability after Built Environment	3.59	32	3.98	27	0.08
Enjoyment after Built Environment	3.49	32	3.88	27	0.08
Community after Built Environment	3.81	32	4.19	27	**0.02**
Efficacy after Built Environment	3.59	32	4.02	27	**0.00**
Usefulness after Jump Rope	4.58	30	4.46	34	0.38
Ability after Jump Rope	4.01	30	3.82	34	0.38
Enjoyment after Jump Rope	3.92	30	3.74	34	0.39
Community after Jump Rope	4.21	30	4.11	34	0.55
Efficacy after Jump Rope	3.91	30	3.92	34	0.95

Note: In Themes 2 and 3, half of sites implemented Built Environment and half Jump Rope Math.