Youth Outcomes of a Program Integrating Math, Sports, and Growth Mindset in Informal Education Settings

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Christina Baze & Seneca Beth Miller

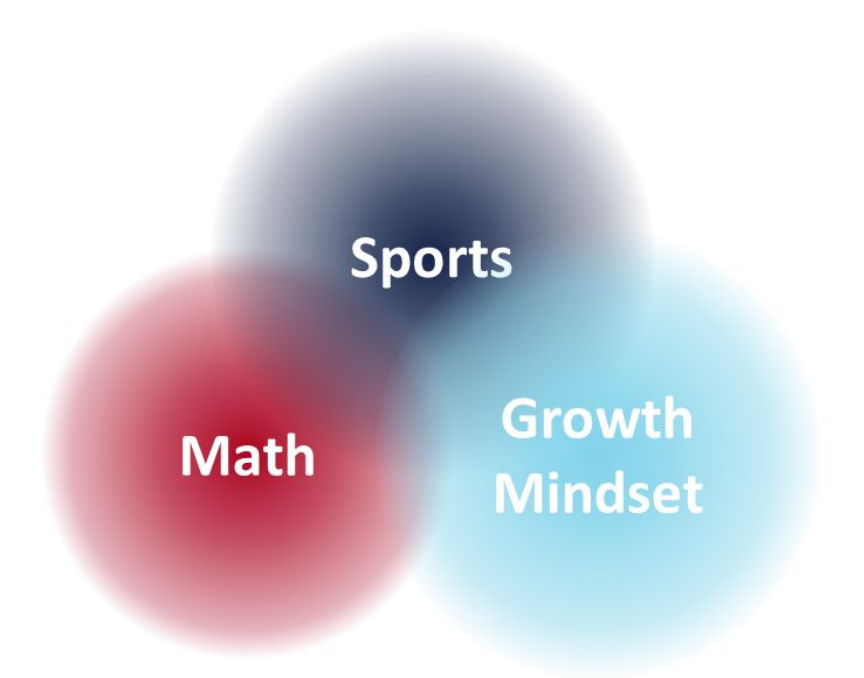
https://shorturl.at/cdfjY

Introduction

- Informal learning settings can be effective spaces to support youths' interest and curiosity in STEM
- Broaden youths' understanding about the relevance and value of STEM in their own lives and the world (Afterschool Alliance, 2013)
    - Buffer against negative experiences with STEM in school (Bathgate & Schunn, 2017; McCreedy & Dierking, 2013)

Background

Growing Mathletes



Background

Developing a growth mindset has positive effects:

- Positive impacts on academic success, particularly decisions to persist when confronted with challenges (Blackwell et al., 2007)
- Learning in school (Blackwell et al., 2007; Dweck, 2012)
- Learning in athletic settings (Biddle, et al., 1996; Sarrazin, et al., 1996)
- Counter dominant narratives about who can and can’t succeed in STEM (Claro et al., 2016; Yeager, et al, 2019)

Methods

Qualitative and quantitative methods used to understand youth outcomes from multiple sites:

	Revision 1		Revision 2			
	FA21	**SP22**	**SU22**	**FA22**	**SP23**	**SU23**
Sites	2 BGC - AZ	2 BGC - AZ	2 Baseball camps - AZ & TX*	1 BGC - AZ	1 STEM program - CA	1 Baseball camp - MO*

Methods

Through this DBIR project, we describe youth outcomes related to:

- Math competency
- Math learning
- Growth mindset related to math learning

Data: pre- and post-program surveys, youth interviews, and observations & artifacts from culminating performance-based tasks

Methods and Analysis - Survey

116 youth completed surveys (paired *t*-tests):

- Items were related to youths' 1) overall growth mindset for learning, 2) **growth mindset for learning math**, 3) growth mindset for learning in sports, 4) ***relevance of math in their lives**, 5) **math competency**, and 6) STEM competency.

- Reliability of item groups were used to confirm previously used groups of items and eliminate items that did not "fit" with these participants.
- *All groups had at least three items except relevance of math in future lives which were two single items used to compare to interview data.

Methods and Analysis - Survey Groups of Items

Anchor Item for Math for All Youth

- I can do well in math even if I am not naturally good at it.

Growth Mindset for Math (R2 only α = .69)

- I can do well in math even if I am not naturally good at it.
- I can change how smart I am in math with hard work.
- I can increase how smart I am in math by challenging myself.
- I am capable of learning anything in math.

Methods and Analysis - Survey Groups of Items

Math Relevancy

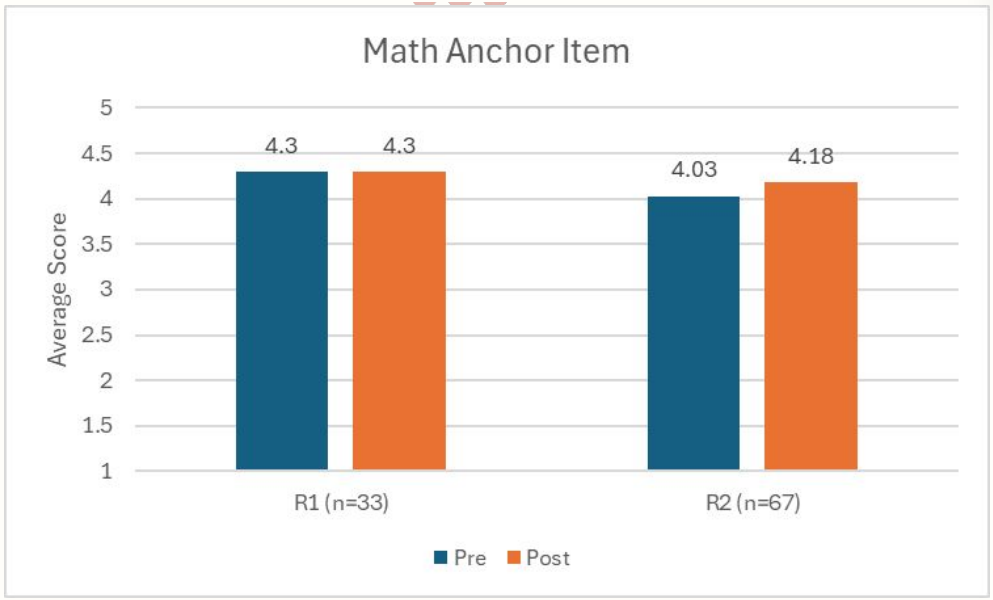
- In the future, I could do harder math problems
- When I’m older, I might choose a job that uses math

Methods and Analysis - Survey Groups of Items

Math Competency (α = .82)

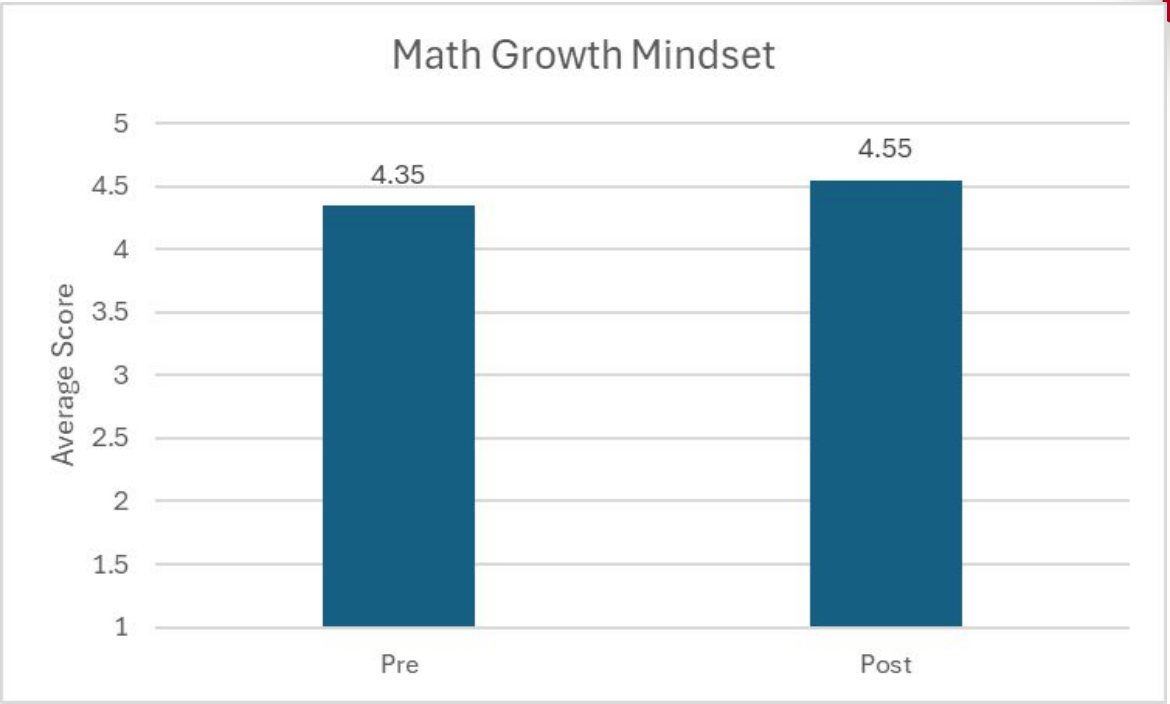
- Math has been my worst subject
- Math is hard for me
- I am the type of student who does well in math
- I can understand most subjects easily, but math is difficult for me
- I can get good grades in math
- I am good at math
- I can use math to solve problems in my life
- I think that I am very good at explaining solutions to math problems

Findings - Survey (Anchor Item for Math Mindset)



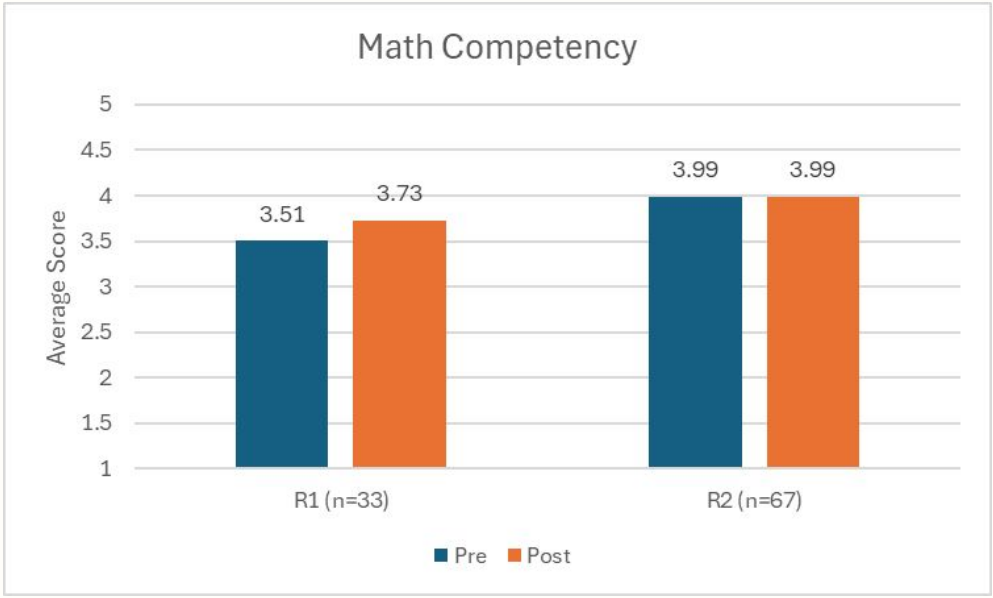
	Pre Mean, S.D.	Post Mean, S.D.	Sig and effect size
Math Anchor, R1	4.30 (1.01)	4.30 (.95)	p>.05
Math Anchor, R2	4.03 (1.13)	4.18 (1.1)	p>.05

Findings - Survey (Math Mindset; R2 only)



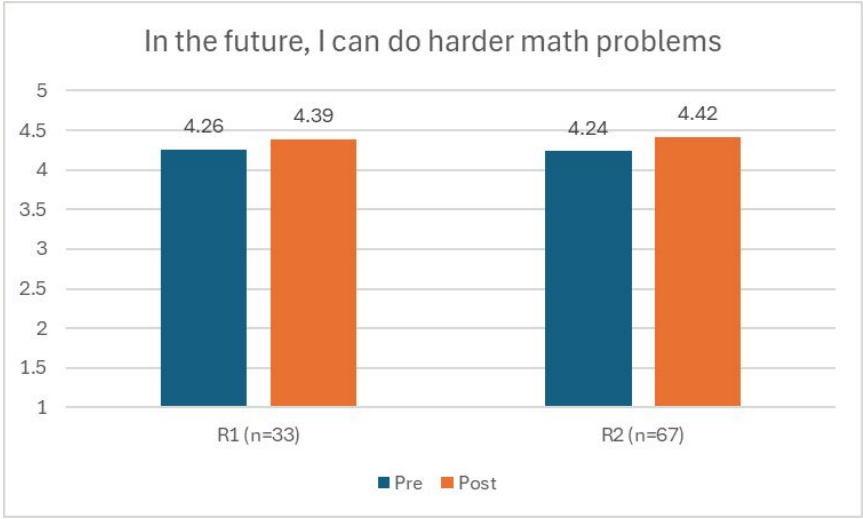
Youth showed a **small, significant increase** in their **growth mindset for math** pre (mean = 4.35) to post (mean = 4.55), $p<.05$ with a small effect size, $d=.28$.

Findings - Survey (Math Competency)



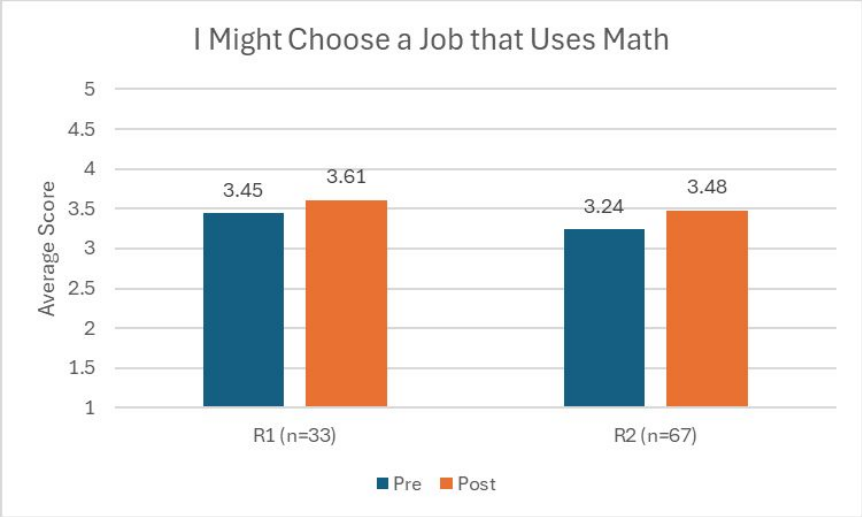
	Pre Mean, S.D.	Post Mean, S.D.	Sig and effect size
Math Competency, R1	3.51 (.98)	3.73 (.96)	**p=.038, d=.32**
Math Competency, R2	3.99 (.63)	3.99 (.68)	p>.05

Findings - Survey (Math Relevance Item 1)



	Pre Mean, S.D.	Post Mean, S.D.
In the future, I can do harder math problems, R1	4.26 (.93)	4.39 (.88)
In the future, I can do harder math problems, R2	4.24 (.98)	4.42 (.93)

Findings - Survey (Math Relevance Item 2)



	Pre Mean, S.D.	Post Mean, S.D.
I might choose a job that uses math, R1	3.45 (1.33)	3.61 (1.29)
I might choose a job that uses math, R2	3.24 (1.33)	3.48 (1.28)

Methods and Analysis - Youth Interviews

At each site, 2-5 youth were interviewed after each session.

Preliminary analysis of 120 interviews from 32 youth from across six different implementations.

- Thematic coding, consensus between 2-3 coders
- Youth math identity and math mindset, athletic mindset, math understanding, math relevance
- Patterns across codes resulted in 10 analytic memos

Preliminary Findings - Youth Interviews

Math understanding

The curriculum offered particular support for understanding **fractions and decimals** but less for topics related to **measurement**.

Math relevance

Youth were able to make **connections** between the math used during the lessons and the use of math in their own lives.

“With chores, for laundry you got to count. How much you need to fold and how much you need to put away."

Preliminary Findings - Youth Interviews

Making Mistakes

You can learn a lot [from making mistakes]. *It helps with your growth mindset. Even if you mess up, it's okay. You still have another chance, especially on the field. You miss a fly ball or grounder, get the next play. … [making mistakes in math] just helps with thinking more, getting you prepared for a next question that might be harder.*

Value of Collaboration

[The activity] was fun. I like the part where we put the cones down because ***it really felt like we were working together****, one was measuring, one was looking at the shape, another one was trying to fix the cones to make sure it was straight, another one was helping the guy measuring, and* ***it was really fun just working as a team****.*

Effort and Persistence

I'm not the strongest at math, but if I try, it could get to my mind and I'll do it. And I'll realize that it's not that hard. But then ***it's like about practice and working on it every day*** *and stuff like that.*

Malleability of the Brain

I kind of think of the brain as a muscle. ***When you flex and work different parts of your brain, they get stronger and they get better and more adept*** *to doing those specific tasks. So when it comes to math, when you're stressing it or when you're working your brain on a specific problem on a calculation. Something like that, and your brain [can] get stronger.*

Methods and Analysis - Capstone Projects

Project Overview

Math & Growth Mindset Concepts

Build a Roster

Design a 9 player baseball roster, compare players for each position on multiple statistics and meet a salary limit.

- Display numerical data in a line plot
- Add and subtract multi-digit numbers
- Read, write and compare decimals to hundredths and thousandths
- Everyone contributes strengths to team

Design a Stadium

Design a stadium, calculate the area of the infield and scoreboard, determine seating capacity and ticket prices and calculate the cost for a family to attend a game.

- Use all four operations to solve multi-step real world problems
- Calculate area of rectangular figures
- Use expressions and equations to represent real-world situations
- Growth mindset supports collaboration

Methods and Analysis - Capstone Projects

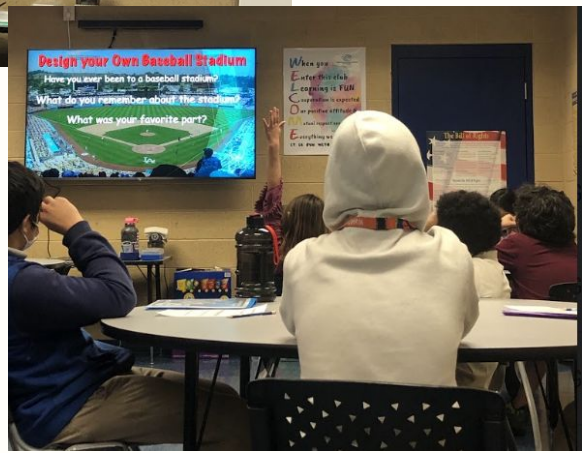
- 14 small groups of youth completed **Baseball Team Roster Project** (approximately 50 youth total)
- 6 small groups of youth completed **Design a Stadium Project** (approximately 20 youth total)
- Completed at 4 implementation sites across 3 states:
  - 2 after school programs
  - 2 summer camps

Methods and Analysis - Capstone Projects

Growing Mathletes

Data Sources:

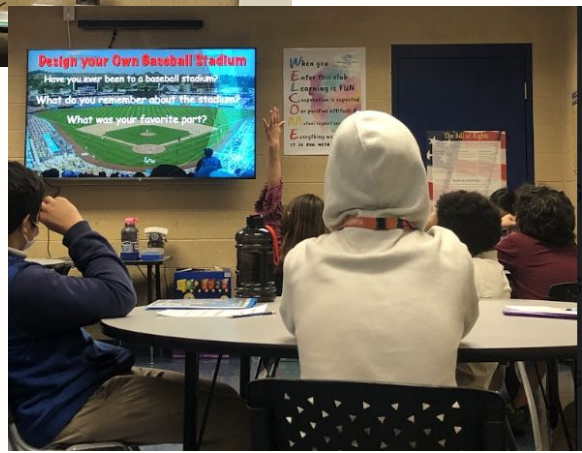
- Video recordings of small groups of youth as they work on performance-based tasks
- Researcher field notes
- Youth's final posters and planning work (worksheets, etc.)



Methods and Analysis - Capstone Projects

Coding and Analysis:

- 2 researchers score each group using a 9 dimension rubric
- Dimensions relate to evidence of math understanding, engagement in math practices, communicating reasoning, equitable participation
- Each dimension scored as no evidence, limited evidence, or strong evidence
- Scoring differences resolved through discussion



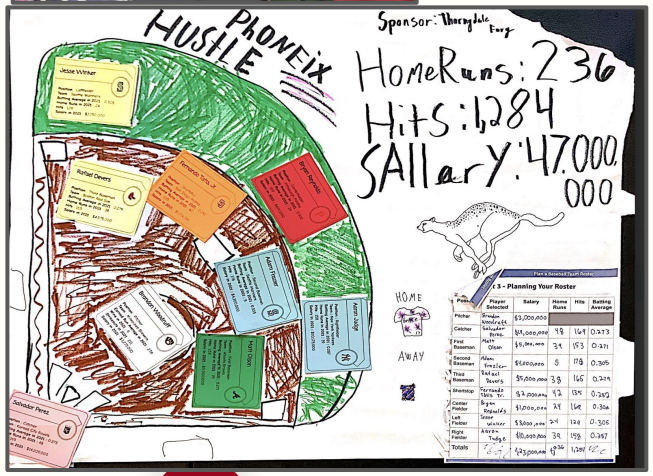
Coding Category	# Groups/ No Evidence	#Groups/ Limited Evidence	# Groups/ Strong Evidence
NUMBER SENSE	1	7	12
OPERATIONS	0	11	9
COMMUNICATING REASONING TO OTHERS	2	11	7
USING TOOLS	6	12	2
PRECISION	7	8	5
ORGANIZING and RECORDING INFORMATION	0	9	11
EQUITABLE PARTICIPATION	1	6	13
CONSIDERING/RESPONDING IDEAS OF PEERS	2	9	9
MATHEMATICAL DECISIONS BASED ON:	No Evidence	Evidence	
• Mathematical Argument	16	4	
• Peer Influence; Peer Recommendation	4	16	
• Facilitator Influence or Recommendation	5	15	
• Personal Experience /Funds of Knowledge	12	8	
• Reasoning across multiple sources of data	12	8	

Findings - Roster Project

Number Sense

Youth evidenced number sense by reasoning across different data points (statistics, salaries) as they compared and selected players for their team rosters. This often involved comparing multiple statistics across several players, and reasoning about large numbers and decimals.

Youth 1: Which one should we pick?
Youth 2: This one's [salary] is 601,000, not even a million.
Youth 3: Yeah, pick this guy, he is cheap and he is good. He has 169 hits, more Hits than the other center fielder, and he has the same amount of Homeruns - 24.
Youth 2: And he has a better Batting Average.
Youth 1: I feel like he's good. He's good for the price.
Youth 2: Yeah, his Batting Average is 0.301. And the other one costs more, but his batting average is only 0.283



Pitcher	Brandon Woodruff	$3,000,000			
Catcher	Salvador Perez	$14,000,000	48	169	0.273
First Baseman	Matt Olson	$5,000,000	39	153	0.271
Second Baseman	Adam Frazier	$4,000,000	5	178	0.305
Third Baseman	Rafael Devers	$5,000,000	38	165	0.279
Shortstop	Fernando Tatis Jr.	$2,000,000	42	135	0.287
Center Fielder	Bryan Reynolds	$1,000,000	24	169	0.302
Left Fielder	Tesse Winker	$3,000,000	24	129	0.305
Right Fielder	Aaron Judge	$10,000,000	39	158	0.287

Findings - Stadium Project

Number Sense

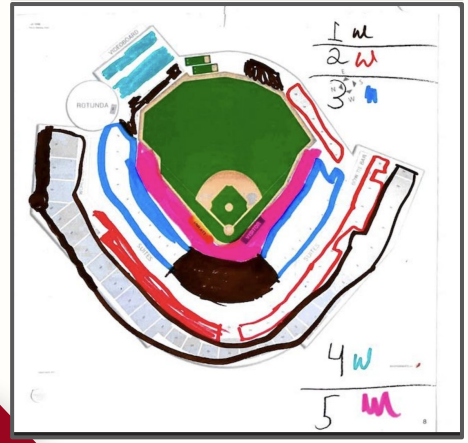
Youth evidenced number sense by selecting, explaining, and appropriately labeling reasonable quantities for their stadium designs, including:

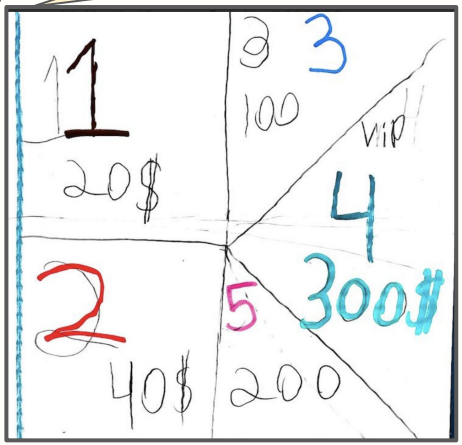
- outfield distances
- ticket prices
- food prices
- seating capacity

Youth selected values that made sense in the context, and reflected prior experiences.

The lower, closer seats should be more expensive because that is where all the action is!

We will offer a family pack. If families have more than 6 or more people, it costs $115.





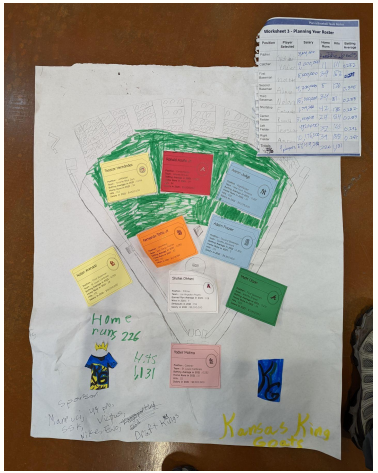
Findings - Roster Project

Operations

Youth are able to successfully use subtraction and addition of large numbers during the roster task while making sure they stay under the cost cap while choosing players. Youth take on different roles in calculations for the task that include both multiplication and addition. Some youth divide the tasks to get the work done while others do a calculation two different ways to get to the same answer.

Y1:I am trying to see how much money we have left – we have 53 million left. ..after the next player we have 48 million left….after the next player we have 44 million left

Some youth do calculations on paper, some do it on a calculator. They compare results to check work of each other.

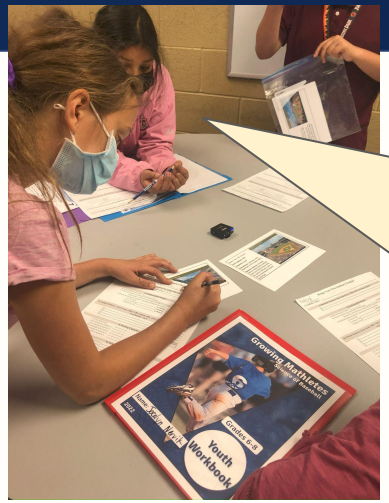


Findings - Stadium Project

Operations

Youth are able to engage in calculations in multiple ways to get to the correct answer for both the stadium task and roster task activities.

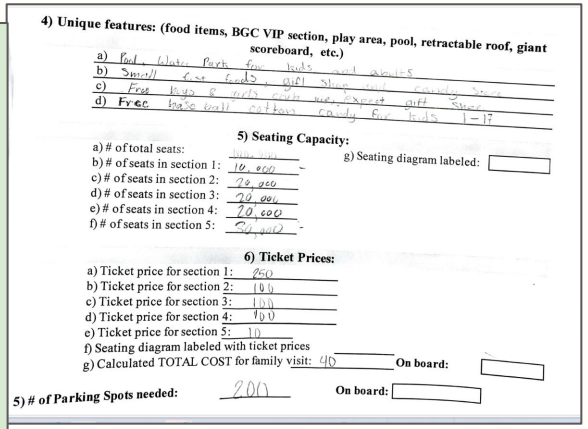
- calculating the area of their field (multiplication)
- calculating the number of seats (addition of large numbers)
- calculating the cost of tickets, food, and parking (multiplication and addition)



Calculating the size of the field
Y1: It's 90x90….which is 8100.
Y2 and 3, We checked the calculation on our phone
Y1: To do it in my head I did 9x9 which is 81 and then I added the two zeros to get 8100.

Youth are able to add the number of seats in each section to find the total number of seats, accurately.

Youth are able to calculate the cost of a group attending a game including cost of tickets, parking, and food


4) Unique features: (food items, BGC VIP section, play area, pool, retractable roof, giant scoreboard, etc.)

a) Pool
b) Small
c) Free
d) Free

5) Seating Capacity:

a) # of total seats:
b) # of seats in section 1: 10,000
c) # of seats in section 2: 20,000
d) # of seats in section 3: 20,000
e) # of seats in section 4: 20,000
f) # of seats in section 5:
g) Seating diagram labeled:

6) Ticket Prices:

a) Ticket price for section 1: 250
b) Ticket price for section 2: 100
c) Ticket price for section 3: 100
d) Ticket price for section 4: 100
e) Ticket price for section 5: 10
f) Seating diagram labeled with ticket prices
g) Calculated TOTAL COST for family visit: 40 On board:

5) # of Parking Spots needed: 200 On board:

Findings - Roster Project

Communicating Reasoning

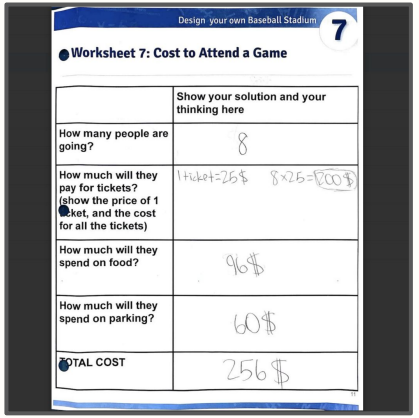
Youth communicated reasoning to defend or explain their choice or perspective about:

- players to include in the roster they created
- ticket prices in the stadium they designed

Youth communicated reasoning to peers and facilitators.

Youth 1: ok 7 million.
Youth 2: his batting average is 305. he only hit 5 home runs.
Youth 1: 28 home runs.
Youth 3: Ok so it is between these two.
Youth 1: I think we should go with him, 7 million and 28 home runs.
Youth 3: Yeah I think we should go with him. Batting average is 253."

Let's change our VIP from $100 to $50 "so that people can actually have the money to come."



Design your own Baseball Stadium 7

Worksheet 7: Cost to Attend a Game

	Show your solution and your thinking here
How many people are going?	8
How much will they pay for tickets? (show the price of 1 ticket, and the cost for all the tickets)	1 ticket=25$ 8×25=200$
How much will they spend on food?	96$
How much will they spend on parking?	60$
TOTAL COST	256$

Findings - Stadium Project

Communicating Reasoning

Youth also communicated reasoning when

- Checking or correcting mistakes and
- Explaining their mathematical processes

Youth communicated this reasoning to peers and facilitators.

"Just do 14 million, you can round that"

You can use a calculator to figure out how much salary we have left!

Youth says "that doesn't make sense" about the total cost of a family attending (I think), then talks through his mental calculations/strategy and the mistake he made. [videos]

Findings - Capstone Projects

Actions Promoting Equitable Participation

The following actions by both facilitators and youth participants promoted equitable participation:

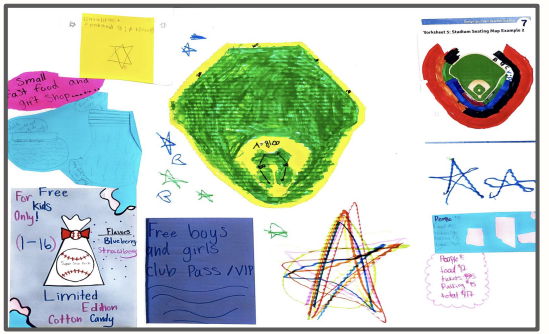
- Making suggestions for how to distribute the tasks so everyone has a role
- Asking participants to shift the pace so everyone is working together on the same task
- Soliciting the opinions and contributions of group members

"You guys are working as a team. It's not just you looking at it, they have to look at it, too."

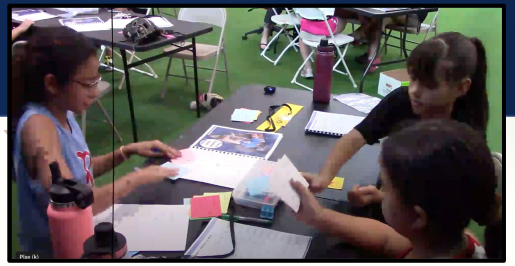
"Hey, girls, you need to help. He drew everything, so now you guys need to, on your field, find your pitcher, his name, what he costs, and why you chose him. Okay?"

~ Facilitator

Girl 1 to Girl 3: Let's slow down. She (Girl 2) is still on part B.
(later)
Girl 1 to Girl 2: Do you have a unique feature you want to add in [to the stadium]?
Girl 2: A rollercoaster and candy shop!



Findings - Capstone Projects

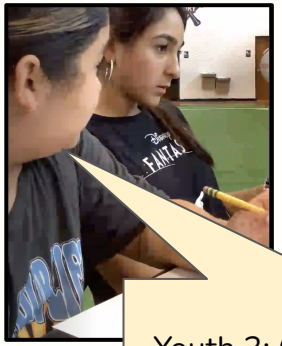


All youth are handling cards.
They decide to each take a set for a given position, and then compare those three players and communicate their ideas to the group.
All are actively engaged in reviewing and discussing the stats.

Forms of Equitable Participation

Equitable participation took the following forms. Youth:

- Took turns: alternating who was drawing on the poster, for example.
- Divided the tasks: distributing the Player Cards so each group member could assess the information individually then share with the group; distributing tasks among youth such as drawing, calculating, and tracking players.
- Made decisions as a whole group.
- Worked in parallel: coloring the poster all at the same time, for example.



Youth 3: Can I do the pitcher?
Youth 1: What catcher do ya'll want?
Youth 3: I wanna pick catcher
Youth 2: We are all gonna pick it together.
Youth 1: You can look at them but we all have to choose together.

Findings - Capstone Projects

Personal Experience/ Funds of Knowledge

When working on an activity to build a roster of players, youth demonstrated and utilized knowledge of players that was beyond what was in the activity. This information included real time information such as which players were currently injured. Additionally, youth had knowledge of players' abilities from their own experience watching baseball.

Thank You and Contact Information

Christina Baze, Northern Arizona University
christina.baze@nau.edu

PI: Ricardo Valerdi, University of Arizona
rvalerdi@arizona.edu

Co-PI: Erin Turner, University of Arizona
eturner@arizona.edu

Website: https://www.growingmathletes.org/

STEM for ALL 2022 Video Showcase:
https://stemforall2022.videohall.com/presentations/2605

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Growth Mindset Principles

1. ***The value of collaboration. Everyone has strengths to contribute to the team.*** Many tasks require a number of different skills and abilities. None of us may have all of these skills and abilities, but as a team we can draw on the strengths of each team member to succeed.
2. ***The power of effort and persistence.*** We can improve and reach our goals through goal setting, effort, and progress tracking. Effort pays off when we persevere and keep working toward goals.
3. ***The value of mistakes in supporting learning.*** Mistakes are a normal and valuable part of the learning process. We can learn from our mistakes through reflecting on our errors and taking lessons from them. Mistakes make our brain grow!
4. ***Malleability of the brain and the role of struggle in learning.*** The brain can get stronger and smarter. New connections between neurons in the brain change all the time as a result of our experiences.
5. ***Praise the process, not the person.*** Modify your language to focus on the process instead of the person. Praise youth when they work hard to accomplish a difficult task.