Making Math Fun: Developing Executive Function Strategies and Math-Positivity Through Gameplay

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Introduction

- Executive functions (EFs) are important for learning, academic achievement, and life outcomes [1].
- Many activities that assess or engage EF are decontextualized, lack meaning, and are not enjoyable for students [2].
- Collaborative games that include academic content may support EF/cognitive strategy use, motivation, and math engagement [3].

We ask:

1. Does a math-based EF-demanding card game elicit EF/cognitive strategy use?
2. What feelings do participants report about math after playing?

Equivacards

With teachers and students, we co-designed a game requiring thinking about mathematical expressions and engaging EF.

- Players match cards (by color and/or number) from their deck to the card most recently played (target card).
- Value of expression cards (e.g., "x + x") are determined by the variable card.

Methods

- Recruited eight participants aged 11-12 from a subject pool in Davis, CA.
- Participants played five rounds of Equivacards online (2-5 minutes/round). In rounds 3-5, participants engaged in think-alouds.
- Five coders used content analysis to code the cognitive strategies participants employed (IRR = 0.88)
- After playing, participants reported their emotions about math.

Child-Reported Demographic Information

Race/Ethnicity	
White	5
Multiracial	2
Hispanic, Chicano/a/x, Latino/a/x	1
Gender	
Girl	7
Did not know	1

Parent-Reported Demographic Information

Highest Educational Degree	
H.S. graduate, some college	3
Degree from 4-year college	3
Graduate/professional degree	2
Household Income	
< $25,000	1
$50,000 – 100,000	2
$100,000 – 200,000	2
> $200,000	3

Cognitive Strategy Codebook

Strategy Markers	Definition	Description	Examples
Planning	Planning for future moves driven by the motivation to win or to be at an advantage to succeed.	Planning for the sequence of a string, whether should save the card for the future, etc.	Participants looked through all the cards except for the variable cards, getting familiar with what they had and trying to think of what they can play [P3]
Inhibiting	During planning, stopping from immediate engagement in a specific action that they have determined is a possible play.	Stop self from playing something when an alternative could lead to a longer string.	Participant paused to reevaluate their cards; considers a card, then inhibits their choice of play [P13]
Cognitive flexibility	Selectively switching attention between different types/categories of information (e.g., color) to generate optimal behaviors.	Shifting from seeing one dimension (e.g., color) of a card to seeing another dimension (e.g., number) on another card or on the same card.	Participant was seeing a card by its value and then shifted to see another card by its color [P10]
Mental calculation	The thinking process involving calculating mathematical expressions with or without the variable X.	When the participant takes some time on calculating whether a card would match the top card by the same number.	Participant calculated the value of a function on a card to see if it could match the target card by the same number [P1]
Scenario testing	When the participant wants to play a card knowing that it does not match the color or number driven by the motivation to win. Or, when the participant clicked on a card by couldn't play it.	Participant clicks the card one or a few times knowing or not knowing that it does not match by the color or number.	Only had one card left and the participant clicked it to try to win, however, the card did not match the color nor number on the target card [P6]
Decision making	Making a selection out of several other possibilities.	Every time the participant makes a decision to play a card or draw a new card.	Participant played another white card for the purpose of depleting; playing this card did not help them to play other cards [P2]

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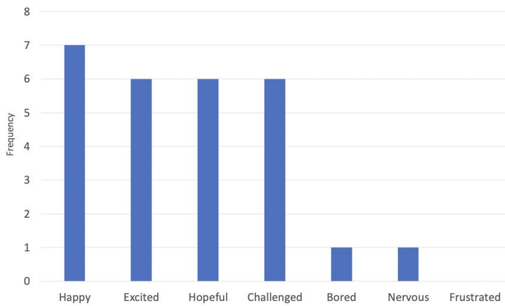
Reported Emotions



Participants responded to the question *"How does playing this game make you feel about math?"* and selected all relevant emotions

Discussion

- Students actively engaged in six cognitive-based strategies during gameplay and reported playing the game made them feel positively about math.
- Games are a promising avenue for engaging mathematical thinking and EF/cognitive strategy use in children and generating positive feelings about mathematics.

Future Work

Conducting a follow-up experimental study to investigate relationships between EFs, game-based performance, voluntary play time, math knowledge, and math-related emotions between Equivacards and a control game.