Developing an Instrument to Measure At-Home Spatial Reasoning

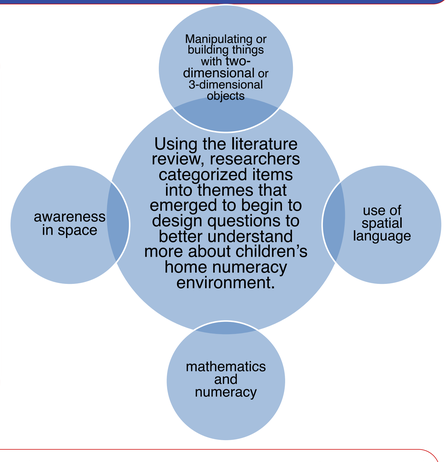
Anthony Sparks, Sarah Wellberg, Josh Geller,
Cassandra Hatfield, & Leanne Ketterlin-Geller (PI)

Background

- Students enter school with a wide range of mathematical abilities, which indicates that children develop skills at home that transfer into the formal mathematics learning that happens in the classroom (Starkey, Klein, & Wakeley, 2004).
- These skills are likely a byproduct of the home math environment, which consists of the numeracy and spatial activities that students engage in at home.
- There are well-documented connections between students' spatial reasoning skills and their mathematical performance (Mix & Cheng, 2012).
- Students with under-developed spatial skills experience greater difficulty with actions such as parsing mathematical symbols, switching between different procedures, and remembering number facts (Rourke, 1993).
- Despite the extensive research demonstrating these connections, the development of spatial skills tends to take a backseat to numeracy activities in the home math environment.
- Zippert & Rittle-Johnson (2020) suggests that parents may simply not realize that spatial skills are an essential part of their child's mathematical development.
- There is a current need for an instrument to better understand students' at-home spatial reasoning skills.
- The purpose of the current study is to develop a survey that aligns to the MMaRS spatial reasoning learning progression for the use of informing practitioners/researchers of students' exposure of at-home spatial reasoning skills.

Initial Development

We searched for literature investigating parents' use of spatial relations activities parents were engaging in with their children at home, along with children's access to certain materials in the home that are linked to spatial awareness. Previous literature revealed ideas and concepts that were specific to, or tangential to spatial awareness and its connections to the home environment.



We utilized these themes and related items to create survey questions based on similar surveys mentioned in the research. The research team modified all items to align with the purpose of the research project. The initial version sent home to parents was 17 questions in length (partially shown below).

	Never	About 1-2 times per **month**	About 1-2 times per **week**	Almost **daily**
1. About how often does your child play with **puzzles**?	○	○	○	○
2. About how often does your child play with **blocks**?	○	○	○	○
3. About how often does your child play with **interlocking construction blocks** (i.e., free play with LEGO™ or DUPLO™ bricks)?	○	○	○	○

Deployment and Findings

As part of a larger effort to collect cognitive interview data to empirically evaluate learning progressions, we distributed the home use survey to parents of 55 consented students in grades K-2 within two schools in a large southern city.

Along we descriptive statistics, we also conducted exploratory factor analyses to better understand the internal structure of the instrument. Results indicated possible issues with over identification due to the small sample size. Therefore, we shifted our efforts to focus on redeveloping the survey.

Factors	CFI	TLI	RMSEA	90% CI	SRMR
1	.918	.906	.129	(.083,.169)	.163
2	.969	.958	.085	(.000,.137)	.114
3	.985	.977	.064	(.000,.126)	.085

Redevelopment

We redesigned the survey to focus only on spatial reasoning. The original survey was highly imbalanced with regard to the number of items associated with the different components of spatial reasoning. We reviewed the literature on the development of spatial reasoning to inform the development of new items that were more representative of skills on the spatial reasoning learning progressions. We created an item blueprint (a portion of which is shown to the right) to help us track the number of items associated with each concept. The frequency scale in the original survey was not appropriate for all of the items, as a child may be able to demonstrate spatial reasoning skills in ways that do not necessarily occur frequently. We developed an independence scale to be used with these items. We also reformatted the survey to so that items that fit together thematically and could use a common stem and scale were grouped (this can be seen in the blueprint image to the right). We hoped that this would (1) reduce the length of each item, making them more accessible and (2) allow respondents to respond to a set of similar prompts all at once rather than mentally jump back and forth between different ideas.

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External Review

We sent the survey to five external reviewers and had them fill out a document in which they evaluated the items and the survey as a whole. They were asked to rate, on a four-point Likert scale, whether each item was: (1) well aligned to the subcomponents we had assigned to it, (2) accessible in its language and visuals, (3) free of bias, (4) culturally appropriate for potential respondents, and (5) associated with an appropriate set of response options. We also asked for overall impressions of how well each of the six core concepts were represented in the survey and for any suggestions for improving any areas that were insufficiently covered.

The responses were generally positive for the sub-component alignment and freedom from bias, but there were some concerns about accessible language and about the cultural appropriateness of some of the examples. There were also major concerns about the scale of the response options.

Next Steps

Our next steps include: (1) revisions to the survey based on external review; (2) translation of the survey into Spanish with a review of the translation for cultural bias and maintaining the original meaning of the items; (3) distribution of the survey to approximately 200 parents through social media outlets, email list, and community centers; and (4) analyses of the internal structure.

Blueprint

Number	Stem & Items	B.5: Spatial Language a	b	c	B.6: Models & Maps a	b	c	d	e	f	g	h	B.7: Perspective a	b	c	d	e	Sub-Components	Core Concept(s) Represented A.1	A.2	A.3	B.5	B.6	B.7
Play	*About how often does your child play with the following items/toys?*																							
1	Puzzles																	3	1	0	1	0	0	0
2	Blocks																	4	0	1	1	0	0	0
3	Board games in which they move a player through a route with other players	1	1	1							1				1			5	0	0	0	1	1	1
Building/Drawing	*Has your child done any of the following activities?*																							
4	Papercraft																	1	0	1	0	0	0	0
5	Drawing maps				1	1	1											3	0	0	0	0	1	0
6	Drawing plans for buildings or spaces				1	1	1											3	0	0	0	0	1	0
7	Drawing a picture from a bird's eye view															1		1	0	0	0	0	0	1
Digital Experiences	*About how often does your child use a computer/video game, app, or interactive website to do the following activities?*																							
8	Build things																	4	0	1	1	0	0	0
9	Organize or arrange shapes (on their own or in combination) to match or fit a space (e.g. play Tetris or Tangrams)																	7	0	1	1	0	0	0
10	Move a digital avatar through space												1	1			1	3	0	0	0	0	0	1
11	Navigate through virtual spaces using a map				1		1		1				1	1				6	0	0	0	0	1	1

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