

Why is MMaRS Important?

Foundational mathematics constructs:

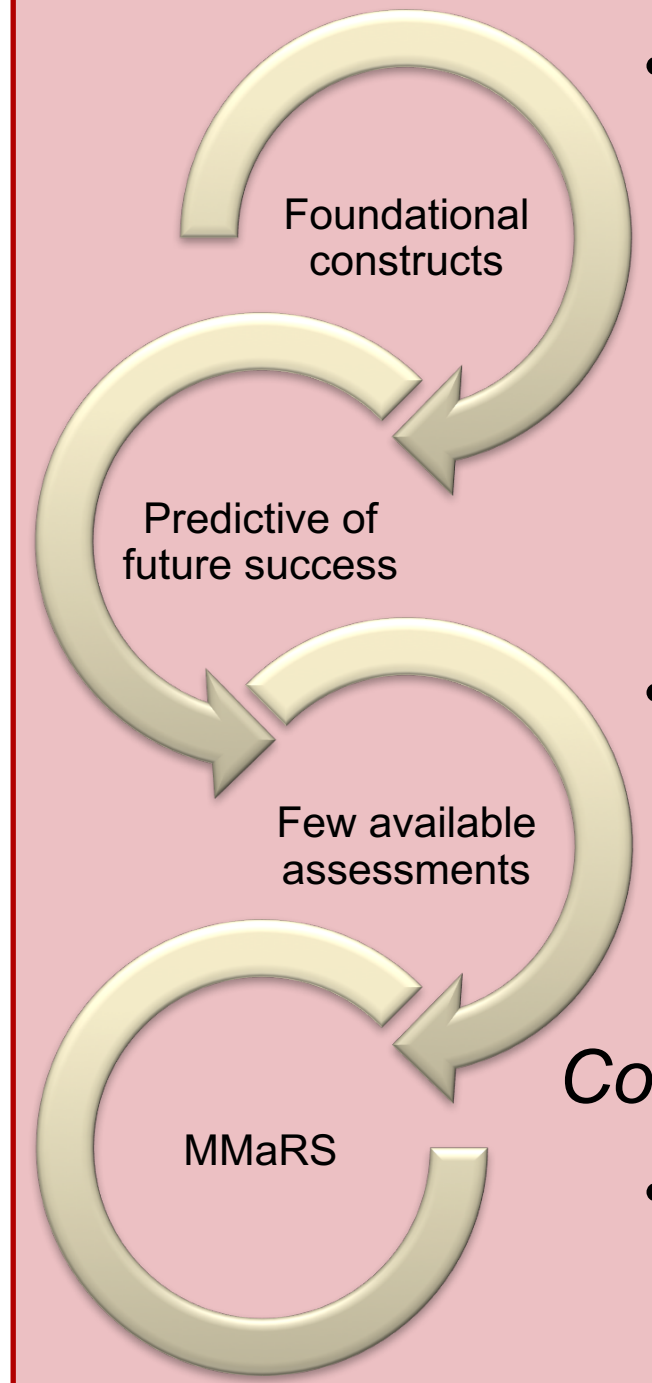
- Numeric relational reasoning and spatial reasoning are foundational mathematical constructs that support the development of other mathematics skills, such as algebraic thinking (Carpenter et al., 2003), place value (Cheng & Mix, 2012), problem solving (Battista, 1990), and number line knowledge (Gunderson et al., 2012), among others.
- Improving students' numeric relational reasoning and spatial reasoning abilities in Grades K-2 has the potential to positively affect students' overall performance in early mathematics.

Constructs predictive of future success:

- Numeric relational reasoning and spatial reasoning abilities are highly predictive of future success in mathematics (Aunio & Niemivirta, 2010; Friedman, 1995).
- Spatial reasoning in particular is predictive of STEM career and college degree selection (Uttal & Cohen, 2012; Wai, Lubinski, & Benbow, 2009).
- Improving students' numeric relational reasoning and spatial reasoning abilities by intervening based on results from the assessments may positively impact mathematics education and STEM outcomes over time.

Few assessments exist that test these constructs.

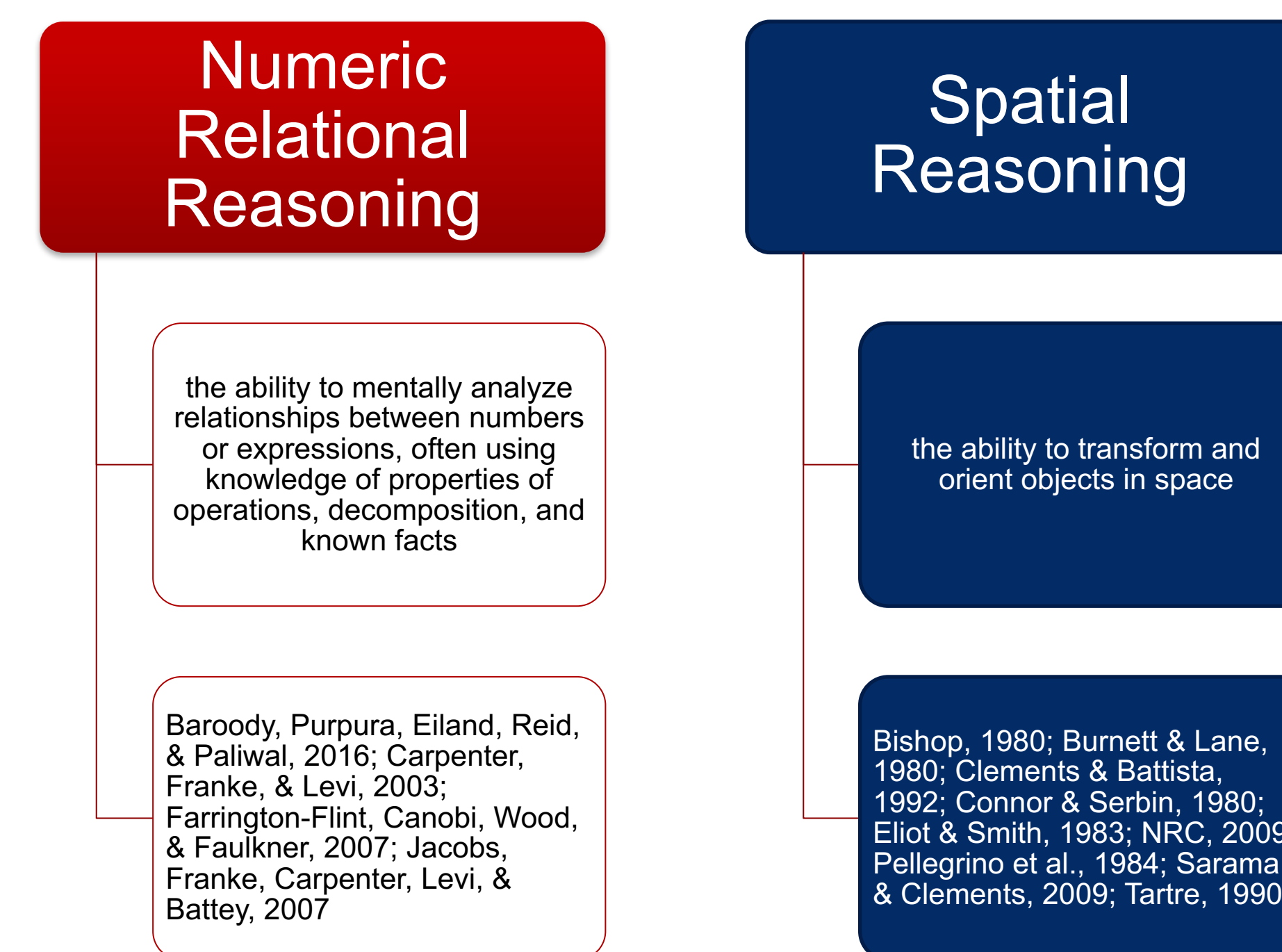
- Few assessments exist that provide teachers with data on Grades K-2 students' numeric relational reasoning and spatial reasoning abilities (Perry, 2016).



Project Goals and Outcomes

To develop and gather validity evidence for mathematics assessments for Grades K-2 that measure students' abilities in numeric relational reasoning and spatial reasoning, and that can be used to assist teachers in instructional decision making.

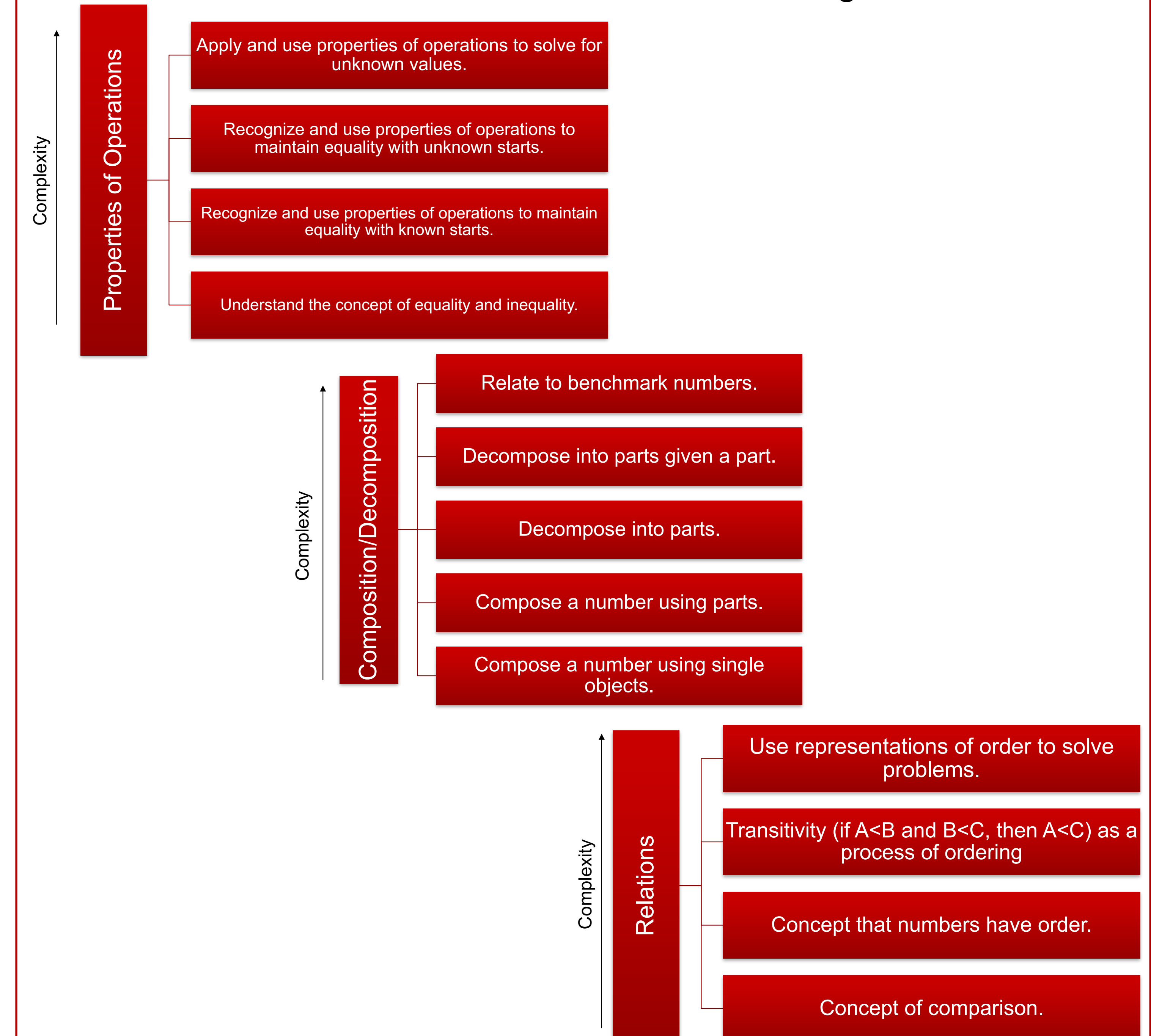
Project MMaRS	
Intended test takers	Students in grades K-2
	Individually administered
Test Specifications	Computer-supported administration
	Three parallel forms at each grade



Learning Progression

- Using the abbreviated construct definition and literature reviews, the SMU team and consultants created an overarching learning progression for each component within numeric relational reasoning and spatial reasoning for K-2.
- These overarching learning progressions are being used to further define the construct at each grade level.

Numeric Relational Reasoning



Assessment Inventory Table

An item inventory was created to catalog current assessments and items that test K-2 students' numeric relational reasoning or spatial reasoning abilities.

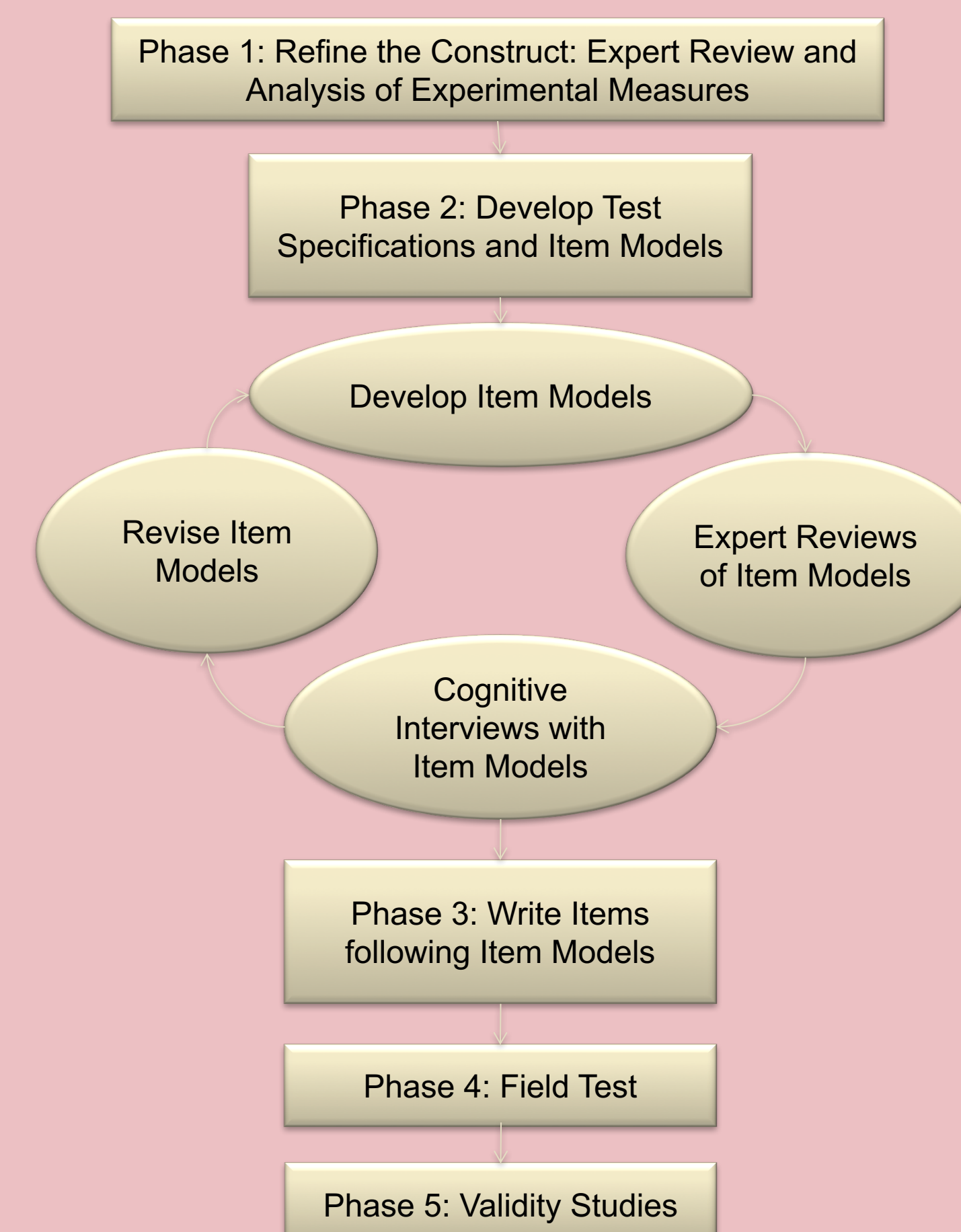
Assessment	Author
Assessment of Mathematical Equivalence Knowledge	Rittle-Johnson, et al., 2011
Open Equations	Powell, 2007, 2015
Preschool Early Numeracy Skills (PENS)	Purpura, 2010; Purpura & Lonigan, 2013
Quantitative Reasoning Test	Nunes et al., 2015
Research-Based Early Maths Assessment (REMA)	Clements et al., 2008
Test of Mathematical Reasoning	Nunes et al., 2001; Nunes et al., 2012
Test of Pre-algebraic Reasoning, Subtest: Equations	Fuchs, Seethaler, & Powell, 2009; Powell & Fuchs, 2014

Assessment	Author
3D Test of Spatial Assembly	Verdine et al., 2014
Children's Mental Transformation Task	Ehrlich, Levine, & Goldin-Meadow, 2006; Levine, Huttenlocher, Taylor, & Langrock, 1999
Mental Folding Test for Children (MFTC)	Harris, Newcombe, & Hirsh-Pasek, 2013
Mental Rotation with Tangible Three-Dimensional Objects	Hawes, Lefevre, Xu & Bruce, 2015
Perspective Taking Test for Children	Frick, Möhring, & Newcombe, 2014
Picture Rotation Test	Quaiser-Pohl, 2003
Spatial Scaling Assessment	Frick & Newcombe, 2012
Wechsler Preschool and Primary Scale of Intelligence III (WPPSI-III): Block Design	Wechsler, 2002

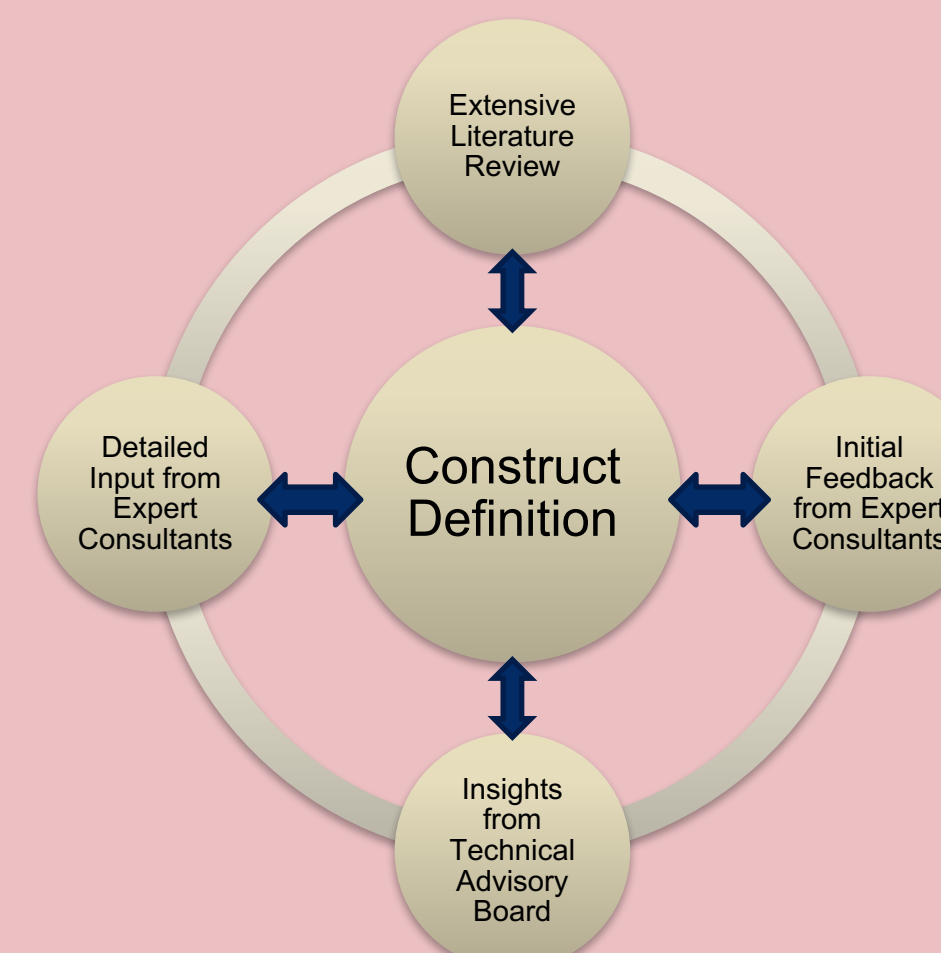
We found that few assessments exist to test students' NRR and SR abilities in K-2. Many of the assessments tested NRR and SR skills within a larger numeracy assessment or were not intended to be used by teachers for instructional decision making.

This project is funded by the National Science Foundation, grant #1721100. Any opinions, findings, and conclusions or recommendations expressed in these materials are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Phases of the Project



Phase I Activities



Phase I Outcomes:

- Literature reviews for Numeric Relational Reasoning and Spatial Reasoning
- Construct definitions for NRR and SR
- Learning progressions for the components within NRR and SR

Next Steps

Looking ahead to Phase 2

- Learning progression refinement
 - Conduct cognitive interviews with students in K-2 to test/refine learning progressions
- Development of item models
 - Develop item models based on learning progressions
 - Conduct think alouds with students to test/refine item models

Spatial Reasoning

