Overview of the Early Math Assessment System (EMAS or The Party)

For the past several years, University of Virginia (UVA) researchers have partnered with the Virginia Department of Education (VDOE) to expand the focus of kindergarten entry assessment in Virginia to include measures of math and social-emotional skills. UVA researchers worked with the VDOE to evaluate options for a math readiness assessment and helped the VDOE select the Early Mathematics Assessment System (EMAS, informally known as the Birthday Party and The Party) (Ginsburg & Pappas, 2016) for statewide use after carefully cross-walking it with the 2016 Virginia Kindergarten Standards of Learning in math (see Table 1 below). The EMAS is a brief, formative assessment that captures math skills at kindergarten entry in the areas of numeracy, operations, geometry and spatial sense, and patterns. Items are written around a theme – a teddy bear's party – designed to keep children engaged with the assessment. Many items include options to provide children with hints or scaffolding so that teachers can gauge what children can do with and without help. Psychometric analyses of the EMAS suggest it provides reliable and valid scores that are associated with child math outcomes (Lee, 2016).

Overview of the Measure and its Constructs

The EMAS is a direct assessment delivered one-on-one by the teacher. The measure includes items across four subdomains of math (Ginsburg & Pappas, 2016). The *numeracy* items capture children's abilities in the areas of counting and cardinality, comparing and ordering, and recognizing and writing numerals. The *operations* items capture children's ability to add and subtract small sets. The *geometry and spatial sense* items capture children's abilities to recognize shapes and their properties, use spatial language (e.g., closest to, farthest from, next to), and understand position of objects. The *pattern* items capture children's ability to reproduce and extend simple patterns.

The EMAS was developed through a rigorous process that included an extensive review of the literature on young children's development of mathematical thinking plus recommendations from prominent state and federal organizations (Ginsburg & Pappas, 2016).

Psychometric Properties of the EMAS

Function of the EMAS. The EMAS was designed with three purposes in mind (Ginsburg & Pappas, 2016). First, it has applications as a formative assessment, meaning that teachers can use EMAS data to provide students with differentiated, appropriate instruction tailored to their individual needs. Second, it can be used to broadly evaluate programs or assess needs across a large group of classrooms; for example, to identify school divisions in need of additional support around early math. Third, it can be used as a screening tool to identify children at risk for difficulties in math. To support these applications, the EMAS authors have conducted careful and extensive work to establish reliability and validity.

Sample characteristics. Psychometric properties of the EMAS were assessed in an ethnically and economically diverse sample of 522 girls and boys ages three, four, and five (Lee, 2016).

Reliability. The EMAS showed good evidence of reliability using three measures (Lee, 2016). Cronbach's alphas showed strong internal consistency ranging from .70 (*patterns*, age 3) to .94 (*number and operation*, age 5), with a median of .90. Test-retest reliability indicated that the EMAS was fairly stable across a two-week period, with coefficients ranging from .24 (*pattern,* age 5) to .82 (*number and operation*, age 4) with a median of .47. Inter-rater reliability was assessed by having two testers independently score the assessments for 47 children. Analyses indicated strong agreement across testers ranging from .71 (*pattern*, age 3 to 1.00 (*shape,* all ages, and *number and operation*, age 3). The median inter-rater reliability was .99.

Validity. Children were assessed on a standardized math assessment (from the Young Children's Achievement Test or YCAT) concurrently with the EMAS in the fall and again in the spring. EMAS scores were positively correlated with concurrent YCAT math scores. Correlations ranged from .32 (*space,* age 3) to .75 (*number and operation,* age 5) with a median of .50. EMAS scores were also positively correlated with later YCAT math scores, ranging from .28 (*space*, age 3) to .66 (*number and operation*, age 4), with a median of .42.

Use of the EMAS in VKRP. In a sample of 10,156 kindergarteners assessed at the beginning of the 2016-2017 school year, EMAS data demonstrated strong internal consistency with an overall Cronbach's alpha score of .91. Subdomain scores also showed high internal consistency with Cronbach's alpha scores of .85 (*numeracy*), .71 (*operations*), .83 (*pattern*), and .77 (*geometry and spatial sense*). Subdomain scores were moderately correlated, with Pearson correlation coefficients ranging from .40 (*pattern* and *operations*) to .61 (*numeracy,* and *geometry and spatial sense*), all significant at the $p < .01$ level.

In addition, fidelity observations conducted in 16 classrooms in Virginia during the 2015-2016 school year indicated extremely high fidelity of test administration with low levels of variability across items. Out of a possible total score of 21, teachers average fidelity score was 19.13. The fidelity items with the lowest average scores were: "materials and preparation of space" (M=2.41, SD=.61) and "following the script in the manual" (M-2.34, SD= .79).

Appendix A

Item-Response Theory Analysis of the EMAS

Item-response theory (IRT) is an advanced statistical approach that allows us to examine the reliability and validity of individual items on a measure in addition to the total score. IRT is useful in determining whether the range of difficulty of the items is appropriate for the students being assessed and provides an additional estimate of the measure's reliability. Researchers at the University of Virginia conducted IRT analyses using Rasch modeling on the 2017-2018 VKRP EMAS data. The sample included 11,790 kindergarten students who were assessed in the fall by their teachers as part of the VKRP readiness assessment. Scores ranged from 0 to 39 with a mean of 30.0 (SD = 7.6) and a median of 32.0. IRT analyses indicated that the EMAS items covered a broad range of difficulty, ranging from -2.57 (easiest) to 1.75 (hardest). The reliability of the items was very high, at .999 on a scale of 0 to 1. Overall, the results suggest that the EMAS is a reliable measure of math readiness for rising kindergarteners in Virginia. The high mean score and the range of item difficulties suggest that the EMAS is more sensitive to children at the low end of the score distribution, which is what was intended for a measure of readiness that helps teachers identify students in need of additional support.

Table 1. Crosswalk of the EMAS with Virginia's 2016 Kindergarten SOLs in math

VA Kindergarten SOL (2016)		VKRP EMAS Items
N/A		Placement of chips into rows and columns on a board to reflect a model (x4)
Number & Number Sense	**K.1 a:** Tell how many are in a set by counting orally	Assesses one-to-one correspondence counting, cardinality principle, and identity principle (x2)
	K.1 b: Read, write, and represent numbers 0 – 20.	Child is asked to write the numbers 5, 7 & 9 (x3)
	K.2 a: Compare and describe one set as having more, fewer, or the same number of objects as the other set	Comparison of two quantities (e.g., which is more: 5 presents or 4 presents?) (x6)
	K.3 a: Count forward orally by ones from 0 to 100	Child is asked to count as high as they can; Stop after child reaches 20 (with option to continue to 100) or child makes errors before reaching 20 (x1)
Computation & Estimation	**K.6:** Model and solve single-step story and picture problems with sums to 10 and differences within 10, using concrete objects.	Addition and subtraction problems are read to the child, with counters placed for help (e.g. "Here are three cookies. If I give you two more, how many cookies will you have altogether?") (x4)
		Addition and subtraction problems are read to the child (e.g. "Four cookies and two more cookies is how many altogether?"). Child has option to use materials for help. (x4)
Measurement and Geometry	**K.7:** Recognize a penny, nickel, dime, quarter	
	K.10 a: Identify and describe plane figures (e.g. circle)	Identification of geometric shapes (e.g. rectangle) (x4) *Note: also covers part of K.10 c SOL*
		Identification of shapes by their attributes (e.g., number of sides) (x3)
	K.10 c: Describe the location of one object relative to another and identify representations of plane figures regardless of their positions and orientations in space.	Nonverbal identification of closest, farthest, between, and next to using a picture with several different animals (x4)
Patterns, Functions & Algebra	**K.13:** Identify, describe, extend, create, and transfer repeating patterns	Reproduction and extension of two patterns (e.g., ABABAB**ABAB**; ABBABB**ABBABB**) (x2)

Table 2. Studies using the EMAS (N = 1)

Study	Study Location	Sample
Lee (2016)	United States	Preschoolers (N=522)

References

Ginsburg, H. P. & Pappas, S. (2016). Invitation to the birthday party: rationale and description. ZDM Mathematics Education, 48, 947-960.

Lee, Y. (2016). Psychometric analyses of the Birthday Party. ZDM Mathematics Education, 48, 961–975.

Additional Publications

Ertle, B., Rosenfeld, D., Presser, A. L., & Goldstein, M. (2016). Preparing preschool teachers to use and benefit from formative assessment: The Birthday Party Assessment professional development system. ZDM Mathematics Education, 48, 977-989.

Ginsberg, H. P. (2016). Helping early childhood educators to understand and assess young children's mathematical minds. ZDM Mathematics Education, 48, 941-946.