Background:

The underpinnings of mathematical competence in children are varied, with support for a number of relevant functions including number sense, working memory, and language, among others. There is less clarity regarding the unique contributions of such predictors, which is important for being able to identify students who may later struggle. There are also unresolved issues regarding the overlap among relevant predictors for mathematics versus reading.

Purpose:

The present study sought to evaluate the varying extent to which number sense, language, and more general cognitive skills are important for developing skill for different mathematical outcomes, and for different reading outcomes. The relationship between predictors was also considered. Finally, the utility of these same predictors for detecting at-risk status was also evaluated.

Setting:

Students from 8 schools and 43 classrooms in a large urban school district.

Participants:

Participants were 189 students recruited from local elementary schools. Students were 6.57 years (SD=1.83) in Kindergarten, and were followed through Grade 1.

Research Design:

This was a predictive longitudinal study. Students were selected from diverse and representative schools and classrooms. Where standardized measures were administered, performance was solidly within the average range; however, outcomes were composites across multiple tasks, not all of which were norm-referenced. Risk status was determined according to -1 SD below the sample mean (approximately 15th %ile of the sample) in six areas of academic achievement.

Data Collection and Analysis:

In Kindergarten, students were administered several measures of number sense (symbolic and nonsymbolic comparison, number naming, oral number sequencing, and counting principles), of language (phonological awareness, rapid naming, vocabulary), and domain general skills (visuospatial working memory, nonverbal reasoning, processing speed, and behavioral inattention). In Grade 1, students were assessed on mathematical (computation, fluency, problem...
solving) and reading (decoding, fluency, and comprehension) outcomes with a combination of norm-referenced, experimental, and school-based measures. Specific combinations of predictors were chosen for each outcome.

The primary mode of analyses was regression (including with mediation), both across the continuum of skill, and logistic regression differentiating struggling from typical students. Achievement and risk status were predicted on the basis of number and cognitive variables. Selection criteria (e.g., sensitivity, specificity, and ROC analyses) were used to identify relative contributions for dichotomous outcomes.

**Results:**

For computation and math fluency outcomes, number naming, counting knowledge, and phonological awareness were unique predictors (all \( p < .05 \), accounting for 33% and 43% of the variance in these outcomes; for problem solving, number naming, symbolic comparison, phonological awareness, working memory, vocabulary, and nonverbal reasoning were unique predictors (all \( p < .05; R^2 = .65 \)). For reading outcomes of decoding, fluency, and comprehension, unique predictors in each model were number naming, phonological awareness, and rapid naming (all \( p < .05; R^2 \) range = .52 to .60).

Number naming appeared in all models, and its influence as a mediator of the effects of the other variables was considered. Number naming showed significant indirect effects for all predictors except vocabulary and nonverbal reasoning in the problem solving model, though the size of these indirect effects were variable in size (range 18% to 54% of the total contribution).

Significant predictors from the above analyses were used to determine their utility for identifying risk status. For mathematical outcomes, areas-under-the-curve (AUC) indices ranged from .88 to .93; for reading outcomes, AUC values ranged from .89 to .92, indicating strong potential for identification, though more stringent criteria lead to reduced sensitivity (and therefore increased false negatives). In general, across these mathematical and reading outcomes, only number naming, counting knowledge, and symbolic comparison were statistically unique predictors of risk status.

**Conclusions:**

The results of this study highlight the role of language-related skills for the prediction of both mathematical and reading outcomes. The contribution of number naming to reading outcomes is likely a reflection of shared processes with letter identification. However, for mathematical outcomes, counting knowledge and more general measures were also predictive of outcomes. A firmer understanding of the processes involved for number-based measures as they relate to different outcomes may help delineate the unique contributions of both, and inform issues related to identification, particularly in the area of mathematics.