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<th>Predicting mathematical performance with working memory, language, intelligence, and home work measures</th>
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<td>Author(s)</td>
<td>Kerry Lee, Ng Swee Fong and Ng Ee Lynn</td>
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<tr>
<td>Source</td>
<td><em>The NIE Researcher, 4</em>(1), 5-8</td>
</tr>
<tr>
<td>Published by</td>
<td>National Institute of Education (Singapore)</td>
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The next set of areas considered important by more than 70% of the student teachers is:

Introduce me to the general structure of the school system and culture (78.5%)
Give me independence to try out new innovative teaching approaches (71.0%)
Provide me information on the various types of resources available for teaching subjects (72.9%)
Let me know the rules and procedures to function effectively in the school (70.1%)
introduce me to teachers teaching the same subjects to get support and help (70.1%)
Show ways to gain students attention and motivate them to learn (70.1%)

This group of 6 areas of help relates to getting information to function effective in the school system. These are also areas where the practitioners are the best source of information to the student teacher to integrate into the school culture and function effective in the school.

The areas listed below were considered importance by less than 70% of the student teachers.

Show me ways to make lessons interesting for different ability classes (64.5%)
Show me how to determine the pace of the lesson for different ability classes (65.4%)
Provide encouragement and support when lessons do not work out well (65.4%)
Show me how to build rapport with the students so as to gain their trust and cooperation (66.4%)
Help in the planning of the lessons in the initial stage of teaching practice (56.6%)

Three of these refers to the techniques of teaching. Perhaps, lower level of importance is given to them because these issues have been covered in the on-campus courses where techniques of motivations, catering for individual differences, pacing of lesson, time management and other

issues related to teaching are discussed at length.

Conclusion
The help considered important may be categories into four broad areas of concern: teaching the curriculum subjects, classroom management, information to function well in the school environment and evaluation of their teaching and feedback. CTs as ground teacher educators need to be aware of student teacher's expectation. McIntyre, Byrd and Foxx (1996) in reviewing the roles of cooperating teachers came to the conclusion that cooperating teachers can greatly influence the student teacher's teaching context and also their behaviour and beliefs in both a positive and negative term. Two important aspects stood out regarding the cooperating teacher's role: the behaviours they exhibit or model and the process and content of feedback they provide to the student teachers. The most effective teachers provide clear specific feedback to their student teachers, provide rationales for suggestions given and exhibit self-reflection.

The finding in this study may be of help to formulate discussion forums to develop mentoring and supervisory skills of CTs and also make them aware of the types of information and help the student teachers desire.

References

Predicting mathematical performance with working memory, language, intelligence, and homework measures

Kerry Lee, Ng Swee Fong, and Ng Ee Lynn

Singapore's primary and secondary students obtained better results than did most of their international peers in the third international mathematics and science study. This is an enviable result and points to a positive educational and social environment. Despite this finding, a sizeable number of students do experience difficulties with mathematics. Several variables are believed to be responsible for individual differences in mathematical abilities: biological (see Geary, 1993, for review), motivational (e.g., Ashcraft, Kirk, & Hopko, 1998) and cognitive (e.g., Shalev, Manor, & Gross-Tsur, 1997). In this study, we examined the degree to which mathematical abilities can be predicted from general cognitive abilities. Specifically, we examined the relationship between working memory measures and mathematical performance.

Working memory, first described by Baddeley and Hitch (1974), is a vital part of our memory network that allows for the representation and manipulation of several pieces of information at a time. It is responsible for short-term memory storage, reasoning, problem solving, and other cognitive tasks that require a consideration of the past and present. The latest version of the working memory models consists of four components: central executive, phonological loop, visuo-spatial sketchpad, and an episodic buffer (Baddeley, 2000). Of particular importance in this study are the first
three components. Recent findings on the relationship between the central executive and arithmetic performance suggest the two are closely linked. Bull and Scerif (2001), for example, showed central executive measures predicted reliably to mathematical performance. Moreover, its contribution was independent of that attributable to reading and general intelligence measures. Other researchers have found that children with poor mathematics abilities also showed deficits in phonological or visuo-spatial abilities (Gathercole & Pickering, 2000; Hoard, Geary, & Hamson, 1999; McLean & Hitch, 1999).

Whereas previous studies had concentrated on fundamental mathematical skills such as counting, number knowledge, and basic arithmetic, we focused on problem solving requiring algebraic thinking in the present study. In Singapore, the introduction of algebraic thinking occurs in the primary school curriculum. To overcome difficulties associated with the kind of logical-deductive thinking characterised by formal algebra, children are taught to translate word problems into pictorial representations. Using this model method, even 9 year olds can be taught to solve challenging word problems. Although the method seems to ameliorate children's difficulties with formal algebraic representation, anecdotal observations suggest considerable individual differences in children's ability to make use of the model method. In this study, we examined whether proficiency in using the model method was predicted by performance on working memory tests. Furthermore, tests of performance intelligence, language ability, and a homework survey were administered as control measures to isolate the unique contribution of working memory to mathematical proficiency.

Method
Participants
One hundred and fifty-one Primary-5 children participated in this study. All children were recruited from schools located in the western zone of Singapore and participated with parental consent. Because of school activities and unexpected absences, a number of children did not complete the whole battery of tests. The final sample contained 146 children (74 boys, 72 girls) with an average age of 10.7 years (SD = .5). An a priori power analysis showed that this sample will yield approximately 95% power (statistical parameters: $\alpha = .05$, medium effect size $f = .15$, 6 predictors).

Children and Procedure
Children were administered a number of tests: a mathematical word problem test devised by the authors, the Working Memory Test Battery (Pickering & Gathercole, 2001), vocabulary and block design (performance IQ) subtests from the Wechsler Intelligence Scale for Children, reading subtests from the Wechsler Objective Reading and Language Dimensions (Singapore), and a homework measure. Because of the length of each test, they were administered over several days.

Mathematical ability
The mathematical test contained ten word problems. Question selection was guided by school curriculum. Because testing was conducted at the middle of the academic year, we selected two questions from the primary 4 curriculum, six questions from the primary 5 curriculum, and 2 more difficult items, from the late primary 5 to early primary 6 curriculum.

Homework
To obtain a measure of the amount of homework performed by children, they were asked to complete a diary. Each page of the diary contained questions on the number of homework questions attempted, amount of time spent on homework, assistance received from caregivers, and similar questions regarding extra-curriculum tuition. Children were asked to fill out the diary for 18 days.

Other instruments were standardized measures. Descriptions of them can be found elsewhere (e.g., Sattler, 2001; Goldman, Osborne, Mitchell, Saunders, & Busch, 1995).

Results and Discussion
Preliminary data screening showed that the verbal IQ measure was highly correlated with the Wechsler Language measure. To avoid problems of multicollinearity, a principal components analysis was conducted to derive a composite language factor score. Pearson's correlations showed that the central executive, performance IQ, and language measures were all strongly and positively correlated with mathematical performance (see Table 1). Of interest was that the homework measure was negatively correlated with mathematics performance. Because the homework measure was also negatively correlated with all other predictors, it is likely that the measure captured an aspect of problem solving.

Table 1: Intercorrelations Among the Study Variables

<table>
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<tr>
<th>Variable</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Phonological component</td>
<td>.206*</td>
<td></td>
<td>.511**</td>
<td>.299**</td>
<td>.575**</td>
<td>-1.73*</td>
</tr>
<tr>
<td>2. Visuo-spatial component</td>
<td></td>
<td>.371**</td>
<td>.396**</td>
<td>.401**</td>
<td>-1.98*</td>
<td>.289**</td>
</tr>
<tr>
<td>3. Central executive component</td>
<td></td>
<td></td>
<td>.348**</td>
<td>.561**</td>
<td>-1.65*</td>
<td>.478**</td>
</tr>
<tr>
<td>4. Block Design</td>
<td></td>
<td></td>
<td></td>
<td>.388**</td>
<td>-2.54**</td>
<td>.492**</td>
</tr>
<tr>
<td>5. Language ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-2.07*</td>
<td>.539**</td>
</tr>
<tr>
<td>6. Amount of homework</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.205*</td>
</tr>
<tr>
<td>7. Mathematics ability</td>
<td></td>
<td></td>
<td></td>
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</tbody>
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Note. * $p < .05$ ** $p < .01$
solving speed. The slower an individual, the more likely he or she is to perform poorly.

The correlation analysis also showed that the predictors were highly inter-correlated. To examine the unique contribution of each variable, a standard regression analysis including all predictor variables was conducted. The predictors accounted for a reliable amount of variation in the mathematics test ($R^2 = .40$, $R^2_{\text{adjusted}} = .38$), $F(6,138) = 15.58$, $p < .01$. Inspection of the regression coefficients

Figure 1

Path diagrams of the relationships between working memory measures, language, performance IQ and mathematical performance.

Panel A

Panel B

Note. *not statistically reliable. Path coefficients are in bold. Figures in standard font denote either variance (when placed above a variable name) or correlation ratio (when placed next to a double-headed arrow).
showed that only the central executive, performance IQ, and language measures predicted reliably to mathematics performance. The semi-partial correlations showed that these three predictors uniquely and respectively accounted for 3%, 6%, and 7% of variation in performance variation on the mathematics test.

To further examine the relationship between working memory, language, intelligence, and mathematical performance, a series of path analyses were conducted. Previous studies suggested that the phonological loop contributed to language development (Baddeley, Gathercole, & Papagno, 1998). Furthermore, language ability has previously been shown to be closely related to mathematical abilities (e.g., Bull, Johnston, & Roy, 1999). These relationships were captured in two path models in which working memory measures were postulated to have both direct and indirect linkages with mathematical performance. The two models differed in that, in the simpler model, the visuo-spatial and phonological components of working memory were hypothesized to have no direct effect on mathematical performance. Variables connected by double headed arrows were hypothesized to be simply intercorrelated. The lack of a connecting line between variables signified no hypothesized relationships. The modified model is presented in Panel A of Figure 1.

Fit indices from AMOS showed that the modified model provided a good fit, comparative fit index (CFI) = .95. Nevertheless, the root mean square error of approximation (RMSEA) index of .14 indicated that the model could be further improved. Inspection of the modification indexes suggested addition of paths from the visuo-spatial component and performance IQ scores to the language factor score (see Panel B of Figure 1). These additions resulted in an improvement in the fit indexes, CFI = .99, RMSEA = .05, p = .40. Consistent across all models were the findings that both language and performance IQ contributed directly to mathematical abilities. Also consistent across all models was the finding that the central executive contributed both directly and indirectly to mathematical abilities. Both the phonological and visuo-spatial components did not contribute directly to mathematical performance, but did so indirectly via language and performance IQ.

Conclusions

From a purely applied perspective, if one were to administer just one set of tests, the language ability tests accounted for more variance in mathematical performance than did other tests administered in this study. However, the data also showed that even when the effects of language and performance IQ were controlled, the working memory measures still provided a moderate but reliable improvement to the prediction of mathematical performance. From a more theoretical viewpoint, findings from the path analyses suggest that working memory abilities are important for both mathematical and linguistic performance. The central executive measure, in particular, was shown to contribute to performance IQ, as well as linguistic and mathematical performance. These findings suggest that one way to improve children's overall performance in these three domains is to target central executive ability. One problem is that central executive ability is usually conceptualized as being fairly multi-faceted. In a follow-up study, we are examining subdivisions within the central executive to see whether different aspects of it contribute to different domains of skill and knowledge.

References


This study is supported by an EdRF grant.