Young Pupils and National Testing: Cognitive Implications for Learning in Mathematics

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INTRODUCTION

In Sweden 2010 national tests for the purpose to promote learning were introduced for grade 3. Although it is unclear how the components of Baddeley's (2000) working memory (WM) model contribute to different operations in mathematics, especially in children, WM is considered to influence scholastic development significantly.

AIM

Examine the contributions of three different components of the WM model of Baddeley (2000) to a range of mathematical skills in children aged 8-9 years taking the Swedish national tests, and to discuss the role of national assessment in primary education.

METHODS

PARTICIPANTS
40 Swedish pupils (20 female, 20 male) in grade 3 participated.

INSTRUMENTS
National tests in mathematics: Written arithmetic, Mental arithmetic, Time, Area and volume, Fraction, and Number understanding. WM tests: Listening span, Digit span, and Block span.

RESULTS

WM explained 41% of the variance for the total mathematical score, F (3,36) = 8.44, p < .001, with significant contribution driven of Block span and Listening span. Written arithmetic was the only test that was not explained significantly by WM, F (3,36) = 2.30, p > .05 (Table 1).

For Mental arithmetic and Number understanding WM accounted for 31% of the variance, F (3,36) = 5.29, p < .01 and F (3,36) = 5.28, p < .01 respectively.

Table 1. Regression analyses with mathematical subtests and WM subtests.

Dependent variables	Independent variables	R^2	β
Math Total Score	Digit Span		-.02
	Block Span		.35*
	Listening Span		.43*
	Total model	.41***	
Written arithmetic	Digit Span		-.14
	Block Span		.31
	Listening Span		.24
	Total model	.16	
Mental arithmetic	Digit Span		.14
	Block Span		.31
	Listening Span		.24
	Total model	.31**	
Time	Digit Span		-.08
	Block Span		.23
	Listening Span		.46*
	Total model	.29**	
Number understanding	Digit Span		.19
	Block Span		.34*
	Listening Span		.16
	Total model	.31**	
Fraction	Digit Span		-.09
	Block Span		.00
	Listening Span		.52**
	Total model	.23*	
Area, volume	Digit Span		-.05
	Block Span		.43*
	Listening Span		.17
	Total model	.24*	

*p .05 **p .01***p .001

The most significant correlation for Listening span was with Time , r = .0501, p < .01, whilst Digit span correlated most strongly with Number understanding, r = .415, p < .01. Block span was found to correlated with Area and volume, Number understanding, with r = .473 and p < .01 (Table 2).

Table 2. Correlations for the WM subtests and the mathematical subtests.

Variables	1	2	3	4	5	6	7	8	9	10
1. Listening Span		.613**	.403**	.284	.452**	.501**	.414**	.472**	.305	.560**
2. Digit Span			.367*	.122	.401*	.285	.415**	.236	.205	.372*
3. Block Span				.356*	.457**	.381*	.473**	.181	.473**	.514**
4. Written artihmetic					.376*	.575**	.375*	.349*	.316*	.723**
5. Mental arithmetic						.521**	.553**	.512**	.283	.758**
6. Time							.522**	.551**	.385*	.810**
7. Number understanding								.480**	.249	.721**
8. Fraction									.140	.752**
9. Area and Volume										.502**
10. Mathematical Total										

*p .05 **p .01

CONCLUSIONS

The contributions of WM resources appear to vary as a function of the mathematical domain, but in certain respect the variance was shared across the elements and the results indicated that both phonological and visuo-spatial abilities are important for mathematical performance.

The understanding of mathematical concepts appears to be closely linked to the phonological loop (Raghubar, Barnes & Hecht, 2010). Written arithmetic (algorithms) significantly correlated only with Block span. Semenza (2008) argues that in written calculation pupils use stored memory including a learned spatial layout schema for arithmetical procedures. Thus, algorithms may be learnt by root and imitation of procedures (Hiebert, 2003). Since algorithms are designed to avoid meaning, the child does not necessarily develop any conceptual understanding of mathematics (Brousseau, 1997).

In contrast, Mental arithmetic and Number understanding, both explained by WM, are considered to be basic mathematical competencies and key components of conventional mathematics (NCTM, 2004).

National tests narrow down a child's achievement in specific school areas, but do not include the didactic aspect. Teachers should consider the cognitive resources of pupils and modify their teaching materials and strategies to accommodate differences in the cognitive aspects of academic competencies.

REFERENCES

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*. 4(11), 417-422.

Brousseau, G. (1997). *Theory of didactical situations in mathematics*. Dordrecht: Kluwer.

Hiebert, J. (2003). What research says about the NCTM Standards. In J. Kilpatrick, G. Martin & D. Schifter (Eds.), *A Research companion to principles and standards for school mathematics* (5-26). Reston, VA: National Council of Teachers of Mathematics.

NCTM (2004). *Principles and Standards for School Mathematics*. Reston, Va.: National Council of Teachers of Mathematics.

Raghubar, K. P., Barnes, M. A. & Hecht, S. A. (2010). Working memory and mathematics: a review of develop-mental, individual differences, and cognitive approaches. *Learning and Individual Differences*, 20(2), 110-122.

Semenza, C. (2008). Number processing. In B. Stemmer & H. A. Whitaker (Eds.), *Handbook of the neurosciences of language* (219-228). London: Academic/Elsevier.

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