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Working Memory: The Reading and Math Connection

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Making Connections: Reading, Math, and Working Memory



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What is Working Memory?

Working memory:

“Provides the temporary storage that underpins our capacity for complex thought” (p. 25).

Baddeley, A. (2006). Working memory: An overview. In S. J. Pickering (Ed.), *Working memory and education* (pp. 1-53). Burlington, MA: Academic Press.

What is Working Memory?

WM is generally conceived as:

- a dynamic mechanism
- that involves the capacity to store information over short periods of time
- while engaging in other cognitively demanding activities (p. 186).

Savage, R., Lavers, N., & Pillay, V. (2007). Working memory and reading difficulties: What we know and what we don't know about the relationship. *Educational Psychology Review*, 19(2), 185-221. doi: 10.1007/s10648-006-9024-1

Working Memory

Is composed of three main parts:

1. Central Executive
2. Phonological Loop
3. Visuospatial Sketchpad

The three component model developed by Baddeley (Baddeley, 1986; Baddeley & Hitch, 1974)

Central Executive

Central Executive

An attentional control system that selects and operates strategies (p. 25)

Baddeley, A. (2006). Working memory: An overview. In S. J. Pickering (Ed.), *Working memory and education* (pp. 1-53). Burlington, MA: Academic Press.

Phonological Loop

Phonological
Loop

A system for holding and
manipulating sound and speech

(p. 25)

Baddeley, A. (2006). Working memory: An overview. In S. J. Pickering (Ed.), *Working memory and education* (pp. 1-53). Burlington, MA: Academic Press.

Visuospatial Sketchpad

Visuospatial
Sketchpad

Functions in a similar role to the
Phonological Loop for nonverbal
material (p. 25)

Baddeley, A. (2006). Working memory: An overview. In S. J. Pickering (Ed.), *Working memory and education* (pp. 1-53). Burlington, MA: Academic Press.

Working Memory

Long Term Memory



Central Executive



Phonological Loop



Visuospatial Sketchpad



The three component model developed by Baddeley (Baddeley, 1986; Baddeley & Hitch, 1974)

Creating Meaningful Literacy Experiences

- Choose a partner for the following activity.
- Say these letters aloud to a friend: P D A Q S M D B T X C J.
- How many your partner can remember.
- Now, say these words to your friend: boy, car, run, see, sun, food, green, phone, hop , the, pencil, by, old.
- How many does your partner remember?
- Now, read this sentence to your friend: I hope it does not start raining before the conference is over.
- Can your partner remember the sentence.?
- Why was it easier for your partner to remember the sentence?
- Your partner probably remembered a few letters, a few more words, but had no difficulty remembering the sentence. The sentence had meaning and was easily understood, comprehended, and remembered.
- Literacy experiences have to be meaningful to them if they are to be understood, comprehended, and remembered.
- Working memory is the mechanism for making connections in cognitive processes.

Reading Connection

Building Blocks of Reading

Cognitive Overload

- Too much time trying to decode
- Not enough time or cognitive energy to comprehend

Working Memory & Learning

An important and consistent finding is that working memory is strongly associated with children's abilities to learn in key academic domains such as reading and mathematics.

(p. 273)

Holmes, J., Adams, J. W., & Hamilton, C. J. (2008). The relationship between visuospatial sketchpad capacity and children's mathematical skills. *European Journal of Cognitive Psychology*, 20(2), 272-289.

Working Memory & Learning

Indeed, marked impairments in working memory function characterize the majority of children with learning difficulties (p. 273).

Holmes, J., Adams, J. W., & Hamilton, C. J. (2008). The relationship between visuospatial sketchpad capacity and children's mathematical skills. *European Journal of Cognitive Psychology*, 20(2), 272-289.

WM Deficits

- A poor attention span and high levels of distractibility but not the hyperactive/impulsive behavior characteristic of ADHD (p. 242).

Alloway, T. P., Gathercole, S. E., Kirkwood, H., & Elliott, J. (2009). The working memory rating scale: A classroom-based behavioral assessment of working memory. *Learning & Individual Differences, 19*(2), 242-245. doi: 10.1016/j.lindif.2008.10.003

WM Deficits

- Difficulties in following instructions
- Remembering the detailed content of ongoing activities
- Keeping track of progress through multi-step tasks
- Seeing through an activity to satisfactory completion (p. 243)

Alloway, T. P., Gathercole, S. E., Kirkwood, H., & Elliott, J. (2009). The working memory rating scale: A classroom-based behavioral assessment of working memory. *Learning & Individual Differences, 19*(2), 242-245. doi: 10.1016/j.lindif.2008.10.003

Identifying WM Deficits

Currently, two major obstacles to the effective identification and management of working memory needs in the classroom are:

- working memory problems are difficult to detect from casual observation alone
- there is an absence of suitable assessment tools that can be used by teachers to identify potential working memory problems

Alloway, T. P., Gathercole, S. E., Kirkwood, H., & Elliott, J. (2009). The working memory rating scale: A classroom-based behavioral assessment of working memory. *Learning & Individual Differences, 19*(2), 242-245. doi: 10.1016/j.lindif.2008.10.003

Testing Working Memory

Working Memory Rating Scale
(WMRS)

Automated Working Memory
Assessment (AWMA)

The Reading & Math Connection

The presence or absence of a reading deficiency is a powerful predictor of the stability of a mathematics disability. (p. 220)

Jordan, N. C., & Hanich, L. B. (2003). Characteristics of children with moderate mathematics deficiencies: A longitudinal perspective. *Learning Disabilities Research & Practice* (Blackwell Publishing Limited), 18(4), 213.

The Reading & Math Connection

A child with comorbid RD/MD at the beginning of second grade is likely to have intractable problems in mathematics throughout primary school, despite special education support. (p. 220)

Jordan, N. C., & Hanich, L. B. (2003). Characteristics of children with moderate mathematics deficiencies: A longitudinal perspective. *Learning Disabilities Research & Practice* (Blackwell Publishing Limited), 18(4), 213.

The Reading & Math Connection

Reading abilities influence children's growth in mathematics, but mathematics abilities do not influence children's growth in reading. (p. 586)

Jordan, N. C., Kaplan, D., & Hanich, L. B. (2002). Achievement growth in children with learning difficulties in mathematics: Findings of a two-year longitudinal study. *Journal of Educational Psychology*, 94(3), 586.

The Reading & Math Connection

Thus it appears that children who start out with specific reading difficulties are at risk for developing secondary or associated mathematics difficulties as they progress through elementary school. (p. 595)

Jordan, N. C., Kaplan, D., & Hanich, L. B. (2002). Achievement growth in children with learning difficulties in mathematics: Findings of a two-year longitudinal study. *Journal of Educational Psychology*, 94(3), 586.

The Reading & Math Connection

What can we do?

- Instruction should use visual strategies to compensate for verbal weakness
- Poor readers also could be instructed in orthographic techniques (memorizing common words in text) which would reduce the need for decoding and aid in comprehension (p. 360)

Kibby, M. Y., & Cohen, M. J. (2008). Memory Functioning in Children with Reading Disabilities and/or Attention Deficit/Hyperactivity Disorder: A Clinical Investigation of their Working Memory and Long-Term Memory Functioning. *Child Neuropsychology*, 14(6), 525-546.

- Offer student friendly definitions of math terms
- Encourage deep processing of word meanings (connections to existing schemata)
- Provide extend opportunities to encounter words
- Enrich the verbal environment of the mathematics lesson (p. 241)

Pierce, M. E., & Fontaine, L. M. (2009). Designing vocabulary instruction in mathematics. *The Reading Teacher*, 33(3), 239-243.

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