Understanding the role of metacognition and working memory in maths achievement

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Background

- Global economic crisis has led to a rise in unemployment, especially in the youth job market
- Wolf report on vocational education (2011) - formal maths qualification used as sifting criteria for course places and jobs
- Every Child A Chance (2009) – maths qualification increases earning potential
- DFE (2010) Low achievement in maths in primary school persists until end of secondary school
Theoretical model

Butterworth, Varma and Laurillard (2011)
• Model suggests the influence of learning experiences on:
  • Biological factors: brain areas related to maths
  • Cognitive factors: memory and some metacognitive processes
  • Behavioural: performance on maths tasks

Demetriou, Christou, Spandoudis and Platsidou (2002)
• Model more specifically highlighted the role of metacognition in problem solving
• Proposed that working memory provides the ‘cognitive space’ for the execution of metacognitive processes
Definitions

- **Working Memory** = a limited storage control system that coordinates verbal and visuospatial material and manages the transfer of information in and out of long term memory (LTM) (Baddeley & Hitch, 1974).

- **Metacognition** = Monitoring the application of cognitive strategies (Flavell, 1979)
  1. Metacognitive knowledge
  2. Regulation of cognition
Maths and Working Memory training/Metacognition interventions

Working Memory Training
- Working memory training studies show improved maths achievement (e.g. Alloway, 2012; Holmes et al., 2009)
- Very new research area

Metacognition Interventions
- Metacognition trained in the context of a maths lesson
- Research shows improvements in maths achievement (Kramarski & Mizrachi, 2006; Verschaffel et al., 2009)
Anxiety

• Maths anxiety is proposed to affect performance on maths tasks (Ashcraft & Kirk, 2001)
• Anxious thoughts (worries) occupy cognitive ‘space’, thus lowering WM capacity (Eysenck & Calvo, 1992) leaving less ‘space’ to process maths information.
• Anxiety can impair MC because if an individual has a high level of maths anxiety they are unable to use their MC knowledge when completing a maths task and thus perform poorly (Veenman, Kerseboom & Imthorn, 2000)
Aims and hypotheses

• Novel contribution: To measure both Working Memory and Metacognition in interventions focused on achieving change in maths achievement.
• Explored intervention’s effect on anxiety and whether this was linked to maths achievement.
• Objective was to inform future maths interventions
• Following previous research, it was anticipated that pupils in both groups would improve their maths scores but that this would be achieved via change in different underlying mechanisms.
• If interventions increased participants’ maths achievement this should be associated with decrease in maths anxiety.
Method

Participants
• 13-14 years old
• Underachieving in maths

Measures
• Wide Ranging Achievement Test (4) – maths subtest (Wilkinson & Robertson, 2006)
• Automated Working Memory Assessment (Alloway, 2007)
• Junior Metacognitive Awareness Inventory (Sperling, Howard, Miller & Murphy, 2002).
• Abbreviated Maths Anxiety Questionnaire Hopko, Mahadevan, Bare & Hunt, 2003).
• Spence Children’s Anxiety Scale (Generalised Anxiety items) (Spence, 1998)
Method

Procedure
- Pre-test in July 2012
- Matched pairs based on T1 maths scores – then randomised to intervention
- CogMed and One to One tutoring delivered to two cohorts
- Post test
- Follow-up 8 weeks later
Analysis

- An independent samples t-test on all T1 data indicated no significant differences between scores on any measure with all ts <1.5 and all ps > .1.
- In addition to considering statistical significance Effect Sizes (ES) as measured by Partial Eta Squared were reported as small (> .01), medium (> .06) and large (> .14) (Richardson, 2011)
- Individual reliable change measures (Jacobson & Truax, 1991)
Results: Maths
Results: Working Memory

![Graph showing the comparison between Working memory and One-to-one over time points T1, T2, and T3, with mean standardised scores.](image)
Results: Anxiety
Understanding change: The link of maths and anxiety
Discussion

CogMed and One to One tutoring

*Significant improvements in:*
- Maths achievement
- Working memory

*Significant reduction in :*
- Anxiety

No significant change in:
- Metacognition

**Maths Improvement in CogMed**
- Consistent with previous research (e.g. Holmes et al, 2009)
- No direct link found between maths achievement and working memory

**Maths Improvement in One to One tutoring**
- Self-regulation - motivation (Eshel & Kovi, 2007; Luo et al., 2011)
- Teacher focus (Chui, 2004).

**Anxiety reduction and improved maths scores**
- Cognitive capacity no longer occupied by anxious thoughts (Eysenck & Calvo, 1992; Eysenck et al., 2007)
Limitations

- Small sample size
- Lack of blinding
- No passive control group (the two experimental groups were effectively active controls for each other)
- Metacognition measure not sensitive enough or perhaps needed to be domain (maths) specific
Implications

- Demonstrated efficacy of interventions studied
- Empirical support for use of One to One tutoring

Future research
- Investigate the impact of factors such as self-efficacy and motivation
- Develop understanding of how anxiety is reduced

Future interventions
- Combine Working Memory and One to One tutoring to maximise improvements
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