Title of Research

An Exploratory Study into the Effectiveness of an Automated Assessment Tool and Software Intervention for Working Memory.

Name of researcher: Michele English

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Research carried out: January - March 2010

Brief outline of research idea (Abstract)

Children who have difficulty storing and manipulating information in the mind over short periods of time are identified as being at risk of poor educational progress. This study aimed to investigate how best to provide support for children with poor working memory. The study was carried out in multiple parts. Part One investigated how best to screen children's working memory function. Part Two involved using a software intervention while Part Three explored teacher response to the relevance of working memory in education. A sample of five children was used. A pre-test, post-test experimental design was the chosen framework for the study. Assessment of the children's working memory was carried out using the Automated Working Memory Assessment (AWMA; Alloway 2007). This software presents a detailed profile of working memory skills necessary for targeting early intervention strategies. Baseline assessments in reading vocabulary, spelling, pseudo-word decoding and mathematics were also carried out to ascertain current academic levels. A software program *JungleMemory* was used for the intervention. This program was used for twenty minutes four times per week. The outcome for each child was studied on an individual basis. The intervention lasted for eight weeks. A questionnaire was used to determine teacher knowledge and awareness. The results of this showed that the majority of teachers would be interested in learning more about working memory. The overall findings of the study indicate that the curriculum would benefit from a core module combining assessment of working memory, cognitive training and the systematic teaching and application of working memory strategies.

Aims and objectives of the research

The main aim of this research was to explore the impact of working memory on academic learning and answer the following research question.

> **What do we know about how children with poor working memory learn and how can we provide interventions to help them reach their potential?**

Arising from this overarching question, the specific objectives of the research were as follows:

1. To explore the relationship that teachers have with technology

2. To examine the efficacy of using an automated working memory assessment tool.

3. To explore the benefits of a cognitive training program for working memory

4. To investigate the potential of teaching meta-cognitive and memory strategies in the primary school classroom

5. To evaluate the perceptions of teachers about the importance and relevance of working memory in education

Methodology

Site, setting and sampling

The research was conducted in a semi-rural national school located outside a large town in the southwest of Ireland. Current enrolment at the school is 281. The school has a permanent staff of thirteen teachers including three Learning Support and Resource Teachers. The pupils also have access to three Special Needs Assistants that work on a part-time basis. The pupils come from a broad range of socio-economic backgrounds and bring a variety of cultures to the school. Five pupils attending learning support with an age profile of 8-13 years participated in the research. Psycho-educational assessments using the Weschler Intelligence Scale for Children IV (Weschler 2003) had identified low working memory and underachievement in their profiles. For this reason they were chosen to take part in the study.

Ethics

As the researcher works in the research location, gaining entry was not an issue. The research proposal was presented to the Board of Management, Principal and teaching staff. A letter outlining the reason for the research, and the likely benefits the programme could have for the students involved was used to get parental consent and support. This letter contained a number of assurances safeguarding the confidentiality and privacy of the participants, as well as an option to withdraw from the research if desired without penalty. The parents were informed that the names of the participants will be changed to protect anonymity. A consent form with an opt-in clause was signed by both parents as well as the children. Once permission was granted there was a follow-up meeting with parents to brief them on the programme and to discuss with them how they could support and encourage their children at home. At the conclusion of the intervention programme, the parents were updated on their child's progress.

Design

A pre-test, post-test experimental design was the chosen framework. Assessment of the children's working memory was carried out using the Automated Working Memory Assessment (AWMA, Alloway 2007). The WIAT II achievement test was used to collect baseline data in vocabulary, comprehension, word reading, pseudo-word decoding and mathematical reasoning in order to ascertain current academic levels. Pre- and post test scores were compared on an individual basis. In this study a control group was not used because there was no matching sample.

Experimental hypothesis

The experimental hypothesis stated that pupils participating in the online intervention programme would obtain higher results on the post-test measures - WIAT II achievement tests and AWMA. The null hypothesis stated that the researcher would not find the experimental results that were anticipated.

Limitations

There are considerable limitations in a small scale study involving a small number of students which will take place in a relatively short time-scale. As the researcher was the teacher involved in the intervention programme, objectivity and fairness had to be safeguarded. This was achieved through careful scrutiny and analysis of data from the research diary, questionnaire and pre- and post intervention assessment of the student's working memory skills and attainment levels. Other limitations included the fact that the intervention only lasted for eight weeks. A two-day mid-term break fell during this time further limiting the timescale. Disruptions to the programme in the form of absences due to sickness also interrupted the continuity.

Procedure

This study was divided into several distinct phases.

1. Selecting data from psychological reports

First and foremost, the researcher examined the psychological reports of the selected participants and counted the number of times key words occurred. The researcher noted the recurring terms and themes which reinforced the centrality of working memory intervention and knowledge of working memory in classroom practice.

2. Assessment

In light of the extensive evidence that working memory is linked to learning outcomes throughout a student's academic career, it is critical to support students who are struggling to learn by first identifying their working memory profile. The Automated Working Memory Assessment provides an effective and reliable way of doing so. The WIAT11 tests provided suitable baseline measurements in key areas.

Automated Working Memory Assessment (AWMA)

The AWMA is the first standardised tool for educators to be able to screen pupils for working memory problems. Its main purpose is to identify significant working memory problems in individuals between 4 and 22 years of age. The administration, scoring and interpretation are fully automated. The AWMA also presents a detailed profile of working memory skills necessary for targeting early intervention strategies. The AWMA supports the idea that working memory functions should be separated. It also explicitly discriminates between short-term memory components and working memory components. In addition the AWMA facilitates the assessment of working memory, making it feasible to screen large numbers of children for working memory weaknesses.

WIAT 11 Weschler Individual Achievement Test (2001)

Measurements were also taken in spelling, word reading, pseudo-word decoding and mathematical reasoning using the WIAT II assessment tests. This test was chosen as it provided a reliable way of measuring attainment on very specific tasks. In order to establish a baseline for the intervention programme, it was important to profile the attainment levels of the target group in English and Mathematics. The researcher was of the opinion that any significant gains in these scores post intervention would be obvious

and useful during the analysis phase of the study. Measurements were taken in spelling, pseudo word decoding, word reading and mathematical reasoning pre and post intervention. MS Excel was used in the analysis of these results.

3. Cognitive training intervention

Working memory capacity has traditionally been thought to be constant. However, research shows promising evidence that cognitive training of working memory using highly systematic computerised training programs can increase working memory capacity. Using a program called *Cogmed*, Torkel Klingberg *et al* (2002) of the Karolinska Institute in Sweden demonstrated that an individual's working memory capacity can be increased with intensive training. Gains were observed among children with ADHD as well as among young adults. These gains may reflect the fact that complex reasoning skills depend on working memory and that training induced improvement in working memory facilitated improvements in participants' reasoning abilities. Tracy Alloway (2009) conducted a study to extend existing evidence of the benefits of cognitive training to students with general learning difficulties. Children who participated in the *JungleMemory* intervention program demonstrated a clear gain not only in working memory tasks, but crucially in learning outcomes as well.

JungleMemory

JungleMemory was selected because of its established validity, ease of use and low cost. It was a suitable software program for an 8 week intervention. *JungleMemory* trains working memory in the context of key learning activities such as reading, letter decoding, and maths. This helps students recognize the value of developing their working memory skills to boost learning in the classroom. *JungleMemory* was accessed on-line three-four times per week by each participant. They used the software for 10-15 minutes at a time. *JungleMemory* consists of three games with up to 30 levels in each game. The student needed to successfully answer 8 out of 10 trials in each level in order to move forward to the next level. The training program adapts to the student's age and ability so that motivation will continue while the student learns.

4. Questionnaires

The teacher questionnaire formed a vital part of this study. It was chosen in order to furnish the researcher with primary source material from teachers working in primary schools. The questionnaire was sent to 120 primary school teachers. It was a very important measuring tool which delivered much relevant quantitative and qualitative data allowing the researcher to understand teacher knowledge and awareness of working memory. A pupil questionnaire was also used following intervention to ascertain the opinions of pupils taking part.

5. Observation, field notes and researcher diary

The intervention program was monitored using field notes. To make the task of documentation more effective, the researcher used a template to jot down details quickly. Behaviours were tracked by recording the observation alongside the subtest associated with it. The study's validity was enhanced when the researcher actively sought evidence that contradicted as well as confirmed the impact of intervention on working memory. These templates became the tools for remembering the events of the day and were very useful when writing reflections into the research journal. After each session, notes and observations were transferred from the template to the journal. The researcher found that keeping a journal was extremely beneficial as it helped in the gathering of a variety of information over the course of the project.

Overview of research findings

Results

The null hypothesis was supported. Pre- and post-test comparative measures failed to point to any statistically significant gain across any of the domains assessed. An eyeball analysis of individual raw scores suggested some gains for most pupils particularly in the area of mathematical reasoning. However, due to the size of the sample these gains did not meet statistical significance in analysis.

Discussion

- The small sample size, the short duration of the intervention programme and the occasional difficulties encountered in accessing the on-line intervention programme were likely influences on the results obtained.
- The AWMA is easy to use and provides a detailed summary of working memory strengths and weaknesses which can guide intervention. The screener and short-form of the test enable efficient screening of a large number of pupils allowing schools to work at a preventative level.
- The study was limited by restricting the measurement of working memory to computerized measures. Incorporating parent and teacher rating scale measures would have provided a more comprehensive version of pupils' working memory functioning pre and post intervention.
- While *JungleMemory* proved to be a motivational intervention for pupils, easy to use and cost effective, it didn't always work correctly and there was a sense of disempowerment when there was no disk to hold.
- Qualitative observations suggest that participants were challenged by and enjoyed using *JungleMemory.* However, on certain occasions due to competing external circumstances pupils did not fully focus on the task of make the expected progress.
- It was observed that while pupils were using the AWMA assessment too and the *JungleMemory* software, metacognitive awareness of working memory was enhanced.

Main findings from the teacher survey

The researcher delivered a questionnaire to one hundred and twenty teachers. Of these, ninety-eight (82%) were returned. The following findings were noted:

1. Working memory and classroom teaching

In the teacher questionnaire, a total of 62 % of Special Education teachers responded that they were familiar with the term 'Working Memory' while only 38% of Mainstream Teachers responded in the affirmative to this question. This finding is significant due to the fact that the majority of low working memory children spend most of their day in the mainstream classroom.

2. Meta-cognition and the teaching of memory strategies

In the teacher questionnaire 78% of respondents had not heard of the term 'meta-cognitive training'. However, a large proportion of teachers surveyed had used strategies that fit best practice for children with poor working memory. In other words at least 94% of teachers had used some form of rehearsal, repetition and rote learning. A large number (78%) had taught reading comprehension strategies and 87% had used paraphrasing as a learning technique. Organisational strategies had been used by 78% and mind-maps had been used by 73%. Sixty-eight per cent of teachers believed that learning should be integrated thematically.

3. General attitudes towards ICT in schools

In the teacher questionnaire 98% of teachers indicated that they thought ICT was effective for enhancing the learning of pupils. This indicates a willingness to embrace technology that could serve well for using computerized assessment as well as well as on-line interventions like *JungleMemory.* A huge majority of teachers also felt that using ICT increased the motivation of pupils, further supporting the contribution that ICT makes to classroom learning. It is interesting to note that almost half of teachers surveyed considered that they did not maximise their ICT resources while 80% of teachers were interested in using an automated assessment.

4. Policy, curriculum and training

The majority of schools (89%) do not have a policy on working memory in the classroom. Therefore the working memory difficulties of many children may go undetected resulting in academic failure down the line. Only 16% of teachers believe that the Primary Curriculum (1999) addresses the needs of children with low working memory. Ninety-three per cent of teachers did not learn about working memory at Teaching College.

Conclusions

1. Assessment of working memory skills may offer a valuable method for screening children likely to be at risk of poor academic progress. Automation of the assessment process could make it easier for teachers to assess large groups of children.

2. Computerised working memory skills training could provide an effective and efficient intervention in the primary school classroom.

3. It is important that there is a stepped approach to identifying working memory difficulties and following through with suitable interventions at as early a stage as possible. If children miss out on reaching crucial milestones in their education it will be very difficult for them to catch up later on.

4. Strategies to support working memory should be built into the core curriculum so that all students can benefit from efficient learning. The teaching of memory strategies should be started at Junior Infant level and built upon as the child goes through the primary school. Early intervention is important as the best time to learn most memory processes are in early childhood and early primary school years.

5. Compensation for difficulties can be made by using good teaching methods such as *direct instruction.* These include:

- Explicit teaching
- Well-sequenced and focused lessons
- Modelling of correct responses
- Reinforcement
- Repetition
- Continuous assessment of performance
- Frequent review of material
- Mastery at each step of the learning process

6. Memory strategies should play a major role in helping secondary school students organise themselves for examinations.

7. At the heart of the implementation of any good curriculum is the quality of the teaching personnel. Thus regular in-service training is important at all stages of the continuum.

8. The improvements recorded in most studies have been based on testing that occurs immediately after training. The long-term effect of intervention is unknown and thus follow-up studies are needed. Achievement gains associated with improved Working Memory would be expected to take time to develop.

Recommendations for further research

- A larger scale study involving a greater number of pupils from a broader range of schools
- An exploration of gender differences and working memory.
- An audit of working memory deficits in pupils attending Gaeltacht and Gaelscoileanna.
- An audit of working memory deficits in EAL students.
- An exploration of the impact of a tailor-made individual intervention based on working memory strengths and weaknesses arising from screening.
- An exploration of working memory with different age-groups.
- Gains in most studies have been based on testing that occurs immediately after training. The long-term effect of intervention is unknown and thus follow-up studies are needed.
- On the basis that working memory underpins learning in children with developmental disorders such as Developmental Co-ordination Disorder, Dyslexia, Specific Language Impairment and ADHD, it would be interesting to conduct research that would demonstrate learning gains in these groups.
- An exploration of the effect of teaching reading comprehension strategies which promote more effective use of working memory resources thus increasing active processing of text.
- Studies targeting the area of higher order thinking skills such as maths reasoning and problem-solving where working memory are very important.
- An exploration of the potential of supporting gifted children in developing their awareness of working memory.
- Studies targeting the potential of the structured teaching of memory strategies such as mnemonics, visualization and organization techniques. Secondary school students who need to absorb and retain large quantities of material for exams would benefit greatly from a greater awareness of how their memory functions.

How the research has contributed to my professional development

Without a doubt this research has made me look at learning in a completely new light. A good working memory is crucial to becoming a successful learner. Thus children with poor working memory require special support as they struggle to meet the demands of the classroom. As a learning support and resource teacher, many of the children that I work with have working memory difficulties. It is important to understand where a child's strengths as well as weaknesses lie and to use this information to identify the required strategies and supports. While I was interested in exploring the benefits of an on-line computerised assessment and intervention it should be noted that in the real world it may not always be practical for schools to have access to this software. I feel therefore that many of the important findings of this study stem not from the results of the computerised intervention but from the teacher survey. I strongly believe that creating awareness of the importance of a 'working memory' approach to classroom teaching is extremely important. Ultimately it is through good quality teaching methods that children learn best. At the heart of every lesson the teacher needs to consider how children learn and how best to maximize their learning potential. Without a doubt undertaking this research has contributed greatly to my professional development.

Benefit to the teaching profession and wider education community

To date information from this research has been/will be disseminated in the following ways:

1. Poster presentation at the IPSA conference, Trinity College (July 2010)

2. Presentation of research to primary school colleagues (September 2011).

3. A two hour presentation of research at the Clare Education Centre at the invitation of the Irish Learning Support Association (November 2011).

5. Publication and presentation of a paper outlining my research as part of the Clare and Limerick Research Conference (March 2012)

Summary of background reading

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