ADDRESSING THE NEEDS OF LOW-ACHIEVING MATHEMATICS STUDENTS:
HELPING STUDENTS ‘TRUST THEIR HEADS’

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Abstract
This paper reports on part of a national numeracy intervention and research program. The program has the generic title QuickSmart because it aims to teach students how to become quick (and accurate) in response speed and smart in strategy use. This intervention seeks to improve automaticity in students' responses which is operationalised as students' fluency and facility with basic academic facts and procedures in mathematics. Improved automaticity can be achieved by reducing working-memory demands on routine tasks, thereby freeing cognitive resources for higher-order processing including the fluent use of mathematical procedures and competent problem solving.

INTRODUCTION
The underlying purpose of the QuickSmart program is to reverse the trend of ongoing poor academic performance for students who have been struggling at school and are caught in a cycle of continued failure. These students experience significant and sustained learning difficulties in basic mathematics despite attempts to overcome their learning problems. An additional purpose of the QuickSmart program is for classroom teachers, support teachers and teacher aides to learn how to significantly improve the learning outcomes in basic mathematics skills of underachieving students in the middle years of schooling. The program offers professional learning support for teachers to work in a small class instructional setting with two students using a specially constructed teaching program supported by extensive material and computer-based resources.

The QuickSmart intervention approach is informed by extensive research findings (e.g., Baker, Gersten, & Lee, 2003; McMaster, Fuchs, Fuchs, & Compton, 2005; Royer, Tronsky, & Chan, 1999). Underpinning the program is the establishment of a motivational learning environment, which emphasises fluency, automatic recall of basic skill information, strategy use, and timed and strategic practice. The aim of the program is to improve students' information retrieval times to levels that free working-memory capacity from an excessive focus on routine tasks. In this way, students become better resourced to undertake higher-order mental processing and to develop age-appropriate basic skills.

QuickSmart supports those students in their middle years of schooling identified as consistently low-achieving. The program runs for approximately thirty weeks with pairs of students involved in three thirty-minute sessions per week. Results of the program indicate that students decrease significantly their average response times, correct inaccurate or inefficient strategies, and develop less error-prone retrieval actions. There is evidence that these results are sustained at least 24 months after the intervention. Findings also indicate that by the end of the program students may exhibit strong gains on standardised test scores of higher-order thinking as well as improvements on state-wide testing measures.

This paper provides a description of the program and then uses recent findings to illustrate its impact on student learning. Two important features of the program are also discussed in some detail in order to highlight the practical and theoretical significance of having students “trust their heads” as learners of mathematics.
STUDENTS WITH LEARNING DIFFICULTIES IN MATHEMATICS

Students who experience ongoing failure face a myriad of difficulties in and beyond their school lives. Those who exhibit consistent weaknesses in basic skills, such as the recall of number facts and other basic mathematics skills, are particularly vulnerable. National test data from Australia provide a compelling case for the need to develop programs that improve numeracy outcomes for students who are performing at or below the National Benchmarks.

Students with learning difficulties in the middle-school years display typically slow and effortful performance of basic academic skills in both reading and mathematics. This lack of facility in reading and calculating reflects inefficiencies in cognitive processes that have far reaching implications across learning, teaching and affective domains. In terms of developing proficiency with basic academic skills, students with learning difficulties (LD) during their middle school years typically make only small gains in learning and classroom performance. Effectively ‘the gap’ between their achievement levels and those of their non-LD peers either remains constant, or more commonly, widens (Cawley, Yan & Miller, 1996; Hempenstall, 2005; Swanson & Hoskyn, 2001).

In the Australian context, where students with learning difficulties do not routinely attract funding or aide support, teachers are increasingly required to make adjustments to their classroom instruction to accommodate students with particular learning needs. Although older students with learning difficulties in reading can find it difficult to access appropriate support, students with learning difficulties in mathematics are doubly disadvantaged because of there are few research-based intervention programs and validated strategies for older students with learning difficulties in mathematics (Louden et al., 2000).

The QuickSmart intervention and research program attempts to fill some of the identified gaps in research and practice regarding middle-years students with learning difficulties. Specifically, QuickSmart aims to provide an intense intervention focused on the basic academic skills that can provide students with the skills necessary to engage more successfully with classroom instruction to accommodate students with particular learning needs. Although older students with learning difficulties in reading can find it difficult to access appropriate support, students with learning difficulties in mathematics are doubly disadvantaged because of there are few research-based intervention programs and validated strategies for older students with learning difficulties in mathematics (Louden et al., 2000).

THE QUICKSMART PROGRAM

Individually designed intervention programs are developed and implemented as part of QuickSmart in order to strengthen students’ problematic skills, e.g., recall of number facts, strategy use, and basic computation. The program is intensive and requires students to work with an adult instructor in pairs for three 30-minute lessons each week for about 30 weeks.

The QuickSmart program:

- is designed to improve students’ information retrieval times;
- frees working-memory capacity from an excessive focus on routine tasks;
- fosters automaticity in basic tasks;
- utilises explicit teaching based on understanding, not rote learning, and deliberate practice;
- has time (as well as accuracy) as a dimension of learning;
- integrates assessment tasks into each lesson with a focus on individual improvement;
- maximises student on-task time in a structured but flexible lesson format;
- provides extensive materials including teaching resources, speedsheets, flashcards; and
- incorporates a computer program called the Cognitive Aptitude Assessment System (CAAS).

In addition to specially developed material resources, QuickSmart uses the Cognitive Aptitude Assessment System (CAAS) to assist in obtaining reliable assessments of student performance. This system was developed at the Laboratory for the Assessment and Training of Academic Skills (LATAS) at the University of Massachusetts (e.g., Royer & Tronsky, 1998). The CAAS software is
installed on a laptop computer and enables precise measurements of students’ accuracy and information retrieval times on numeracy tasks. Specifically, the CAAS system provides measures of how rapidly students complete tasks by speaking into a microphone once a number fact appears on the computer screen. An instructor scores each response for accuracy. Students’ assessment results are automatically averaged per item and made available in either a graph or report form that is easily interpretable by both students and teachers. The CAAS is a unique component of the QuickSmart program. It provides on-going monitoring of students’ basic academic skills during lessons and supports the instructional focus of the QuickSmart intervention when used for data collection at pre-test and post-test.

The professional development program accompanying QuickSmart is focused on supporting teachers, aides and school administrators to understand and provide:

- effective instruction that maximises student on-task time;
- learning scaffolds that ensure students experience improvement and success;
- deliberate practice integral to every lesson that allows for success and is focused on providing targeted feedback to improve learning;
- guided and independent timed practice activities;
- strategy instruction and concept development;
- the importance of confidence to their students by encouraging a ‘can do’ attitude;
- appropriate teacher and peer modeling; and
- motivational academic activities that are opportunities for developing procedural fluency.

As a consequence of the project and professional development experiences, teachers learn to:

- use time as a dimension of learning and practice;
- incorporate concepts of automaticity (Quick) and accuracy (Smart) regularly in their teaching;
- structure learning activities to help encourage success;
- address individual student needs in their planning over an extended period;
- assess and monitor student needs unobtrusively in their teaching programs;
- create a highly motivational learning environment for students;
- integrate assessment tasks into each lesson, alongside a non-competitive focus on individual improvement; and
- design and develop activities that improve students’ information processing abilities by freeing up working memory resources.

**METHODOLOGY**

The QuickSmart program aims to narrow the gap between the learning achievements of the targeted QuickSmart students and their average achieving peers. This paper focuses on the results of the intervention from three participating schools in the New England region of New South Wales.

**Student Selection for the QuickSmart Program.** A total of forty-two students, 22 girls and 20 boys, enrolled in middle school grades (Grades 5, 6, and 7) across three schools from a large rural town in New South Wales were selected to participate in the QuickSmart numeracy intervention. The average age of participating students was 11 years and 7 months. Eleven students identified as Indigenous Australians.

Students were selected to participate based on their state-wide testing results, low scores on pre-intervention individual standardised tests (the Australian-normed Progressive Achievement Tests, ACER 2001), and nomination by their class teachers as students experiencing learning difficulties. These students demonstrated a lack of confidence and progress in basic mathematics activities.

**Comparison Student Selection.** Ten average-achieving students provided a comparison
for the QuickSmart intervention group. The decision was made on ethical grounds to include as many students experiencing learning difficulties who qualified for the intervention as possible instead of randomly assigning students to intervention and control groups. Thus a comparison group of average achieving students who received classroom instruction was selected to provide a benchmark in terms of response speed and accuracy on CAAS assessments and to explore students’ skill improvement on standardised test scores.

Pre-Test and Post-Test Assessments. Pre-intervention and post-intervention testing of both the selected QuickSmart students and the comparison students was completed using the standardised Progressive Achievement Tests (PAT) (ACER, 2001) in mathematics and and a bank of mathematics tasks from the Cognitive Aptitude Assessment System (CAAS) computer assessment package (Royer, 1996; Royer & Tronsky, 1996).

The QuickSmart Intervention. Before the intervention began QuickSmart students were grouped into pairs of similar ability. Students then participated in approximately thirty weeks of structured intervention activities in small groups of two students. An experienced teacher or teacher’s aide delivered the program under the supervision of a coordinating teacher to ensure the fidelity of the intervention. Each small group of students attended three, thirty-minute sessions per week for the duration of the QuickSmart program.

QuickSmart intervention sessions were made up of a variety of short, focused activities that aimed to increase students’ strategy use and improve their automatic recall of basic number facts across all four operations. Mathematics intervention sessions included timed recall of basic number facts from a targeted set of focus number facts, speed sheets that also related to the same set of focus facts and included extension number facts (e.g. 50 x 5; 300 ÷ 6), opportunities to consolidate the use of strategies for calculating number facts, the use of a prompt scaffold to solve mathematical problems, and regular testing on tasks from the CAAS bank of mathematics tasks.

RESULTS

Information related to students’ accuracy and information retrieval times as measured by CAAS tasks was collected to provide a measure of students’ levels of automaticity of basic academic skills. Students’ pre-test and post-test standardised PAT scores were also gathered. These scores were used as an indication of students’ capacity to engage successfully with more complex tasks such as mathematical problem-solving. All test results were supported by the collection of rich observational data, semi-structured exit interviews and field notes. The discussion of these qualitative data, however, is beyond the scope of the current paper.

Standardised Test Scores. The Progressive Achievement Tests (ACER, 2005) in mathematics were administered to students participating in the QuickSmart program and also to an average achieving comparison group of their peers. In this study thirty-seven of the forty-two participating QuickSmart students increased their post-test percentile rank scores. Individual improvements of up to 48 percentile points were noted.

These results illustrate the extent of the performance gap that exists between students with learning disabilities and their average achieving peers. At pre-test the QuickSmart numeracy groups’ average score was 35.01 percentile points lower than those of the average achieving comparison students. At post-test, this difference was 21.60 percentile points lower. Small and unequal sample sizes precluded further quantitative analyses of data comparing the QuickSmart and comparison groups. It is interesting to note, however, that the individual group mean of QuickSmart (n = 42; post-test mathematics score mean = 44.24 (20.1)) and average-achieving students (n = 10; post-test mathematics score mean = 49.5 (18.76.) indicate that compared to average students’ mean pretest scores QuickSmart students had begun to ‘narrow the gap’ over the course of the intervention.

Paired sample T-tests indicated that the QuickSmart students’ post-test scores were significantly higher than their pre-test standardised scores on measures of mathematics (t(1, 41) = 6.8 p = .000). In contrast, the comparison students did not make significant gains on the standardized measures of mathematics over the course of the intervention (t(1, 9) = 0.46 p = .653). These findings can be interpreted as support for the position that improving students’ accuracy and automaticity of basic academic skills, which was a focus of the QuickSmart program, can result in increased performance on standardized tests designed to measure proficiency on more complex skills.
**Cognitive Aptitude Assessment System Data.** The CAAS system records data relating to students’ retrieval times and accuracy levels on key academic tasks. For the QuickSmart numeracy group, the tasks used were addition number facts, subtraction number facts, multiplication number facts, division number facts and triple addition tasks (e.g., $7 + 4 + 3$). Assessments on all of these tasks were completed before and after the intervention with students from the QuickSmart group ($n = 42$) as well as their average/high-achieving peers ($n = 10$). In addition, students in the intervention group completed selected CAAS assessments as a usual part of their QuickSmart lessons.

Comparison of these pre-test and post-test scores shows that the average performance of QuickSmart students improved markedly in terms of their immediate recall of basic mathematical facts and the accuracy of their answers. For example, with regard to multiplication number facts, the students in the QS group were able to respond in an average time of 2.2 seconds by the end of the QuickSmart program. At the beginning of the intervention, these same students took an average of 3.5 seconds to answer each number fact. The students’ accuracy also improved from an average of 76% at the beginning of the program to 89% for correct multiplication number facts at the end of the intervention. Again, these scores are indications of how QuickSmart students were beginning to ‘narrow the gap’ in terms of basic academic skills by becoming ‘quicker’ with fact retrieval and ‘smarter’ at strategy use.

**DISCUSSION**

QuickSmart focuses on improving the automaticity of basic academic skills of students with learning difficulties in their middle years of schooling. The results presented indicate that students who completed the QuickSmart program were able to achieve a profile of performance on CAAS response speed and accuracy measures similar to that of their same-age peers. Though further work with a larger cohort of comparison students to address concerns about external validity, and more rigorous statistical analyses have are subsequently underway, this study demonstrates that carefully designed explicit interventions of sufficient intensity and duration, such as QuickSmart, are important ways to support students with learning difficulties. They can begin to bring students ‘up to speed’ in terms of efficient processing. This result is counter to research (e.g., Geary, 1996; Spear-Swerling, 2005; Westwood, 2003) that suggests the ability to retrieve basic facts does not usually improve across the elementary-school years for most students with learning difficulties. Providing frequent opportunities for practice, for feedback and for fluent performance supported QuickSmart students as they moved from being unsure of basic academic knowledge and reliant on inefficient strategies to being able to “trust their heads”, as some participating students termed it, because automatic recall had been established.

It appears that even small decreases in the time that it takes students to complete basic number fact tasks can accrue benefits. These benefits associated with increased efficiency of working memory include more successful engagement with complex tasks and a stronger sense of control over learning. To illustrate, during an interview at the end of the QuickSmart program one of the students exclaimed with surprise, “I didn’t know I could do that. I thought I was guessing if I said the answer that just came into my head.”

How students’ improvement on basic academic skills like number facts recognition influenced their ability to tackle more demanding tasks like mathematical problem-solving was investigated through the administration of standardised tests normed on a population of Australian school children. These tests were included as a way of gaining some insight into whether students’ higher-order thinking had improved alongside their automaticity with basic academic skills. Whether standardised tests are an appropriate measure for accessing students’ improvements in cognitive processing can be debated. They are, however, ecologically valid measures that were independent of the researchers and the major intervention focus on developing automaticity. The statistically significant improvements of the QuickSmart numeracy group on these measures of more generalized mathematics knowledge, skills and understandings, indicates that students had become more able to complete these kinds of tasks successfully by the end of the intervention. This improvement was not evident in the scores of the average students in the comparison groups. Though this gap between the comparison and QS students remained at post-test, it had narrowed. This finding has value at a time in Australia when state and national testing agendas are increasingly pervasive.

Due to the persistent nature of their difficulties, it is unlikely that middle-years students with LD will ever ‘catch-up’ entirely with their non-LD peers in terms of academic achievement. Perhaps a worthy aim instead is to attempt to ‘narrow the gap’, so that the achievement levels of LD students
are closer to those of their non-LD peers. The results of this research suggests that a focus on improving basic academic proficiency through a targeted intervention has considerable potential because it boosts the kinds of skills that are necessary for more complex tasks and which are assumed to already be in place for middle school students. Curriculum demands and the diversity of student needs in the classroom generally do not allow teachers the time to organise and oversee instruction with the specific focus, fast-paced opportunities for practice, and individual attention to progress that QuickSmart offers. Many of the activities in QuickSmart lessons can and are used in classroom settings. The small group instruction described in this paper, however, presents an alternate way of addressing the learning needs of students experiencing learning difficulties by consolidating their knowledge and confirming their proficiency so that they are ultimately more able to benefit from classroom instruction.

In terms of Australian research into learning difficulties, QuickSmart is an example of a fourth phase teaching intervention designed for students with academic difficulties in the middle years of schooling whose difficulties have not responded to the assistance offered by their teachers, consultants, and classroom-based learning support programs (see Louden et al., 2000). It offers a different model of intense, focused, small group instruction over an extended timeframe. In this way, QuickSmart represents an alternative to current initiatives that focus on quality teaching and teacher development by addressing the needs of middle school students directly. The QuickSmart program is individualised, carefully monitored and accompanied by professional development opportunities for teachers, aides, support teachers and other members of school communities.

FURTHER QUICKSMART RESULTS

In 2006, with Federal Government support the QuickSmart program was expanded to include approximately 300 students from the Northern Territory (NT) and New South Wales (NSW). In the NT 203 students were included in the program alongside 111 comparison students. In NSW at a public high school, 87 Year 7 students who were identified as not meeting National Benchmarks, took part in the program. Many of these students in both settings were Indigenous.

The graph below prepared by a senior Curriculum Officer Numeracy from the Teaching, Learning and Standards Division compares pre- and post-scores on a basic skills test for the QuickSmart cohort and groups of average-achieving comparison students.
Figure 1: Northern Territory Results from the 2006 intervention

The graph illustrates the gains made by the QuickSmart group of students compared to their average-achieving peers. The two groups were statistically significantly different from each other at the start of the program but were not statistically different on the post-test.

Finally, it is important to reporting on the parents’ perceptions of the QuickSmart program in order to “bring to life” the results already presented. Parents were interviewed about how their children reacted to the QuickSmart program. In all cases their views were positive. Examples of parent’s comments included:

Parent 1  Our daughter thought she learnt heaps. It helped her greatly. We appreciated the opportunity the program offered and we believe the benefits for our child were great.

Parent 2  He told me how well he was doing and how he was improving. His speeds were getting better and so was his accuracy. He enjoyed the work on the laptop. Yes, it was a good experience for my son and he is a lot more confident in his approach and more willing to take risks with his maths.

Parent 3  Joe told us about his lessons. He is very proud of his progress. It is a good program and should continue for a longer period.

Parent 4  My daughter has improved her basic maths knowledge. She no longer uses her fingers. I believe she has learnt a lot. She enjoys maths in the normal classroom now.

These comments indicate that parents perceived improvements in their children’s Mathematical skills that went far beyond accuracy and retrieval times for number facts. Many of the parents commented on an increase in personal confidence that their children felt as a consequence of the QuickSmart intervention. The realisation by students that they can learn mathematics, and that they can play an active and positive role in the classroom, was routinely commented upon by students and their parents. Towards the end of the QuickSmart program, for example, one particular student observed that he could “now think like the brainy kids.” It is comments such as this that imply the greatest possible long-term value of the QuickSmart program: By encouraging students to “trust their heads” in answering mathematics facts and to increasingly see themselves as successful learners, QuickSmart brings about changes in self efficacy for students based upon their realization.
that they have made (and can feel) genuine improvements in their learning and their understandings.

REFERENCES


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