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

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ABSTRACT

This paper is based on a national intervention and research program. The program has the generic title *QuickSmart* because it aimed 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. This is achieved by reducing working-memory demands on routine tasks, and freeing cognitive resources for higher-order processing, using mathematical procedures and problem solving.

The *QuickSmart* program 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. The results also indicate that by the end of the program these students exhibited strong gains on standardised test scores of higher-order thinking as well as improvements on State-wide testing measures neither of which were the focus of instruction. Finally, there is evidence that the results are sustained at least 24 months after the intervention.

This paper provides the background, theoretical basis, and description of the program, as well as findings from 2006. Four important aspects of the program are also discussed that we believe contribute to its success, have important implications for classroom practice that are most likely to facilitate improvements in students' learning, and highlight the practical and theoretical significance of having students "trust their head".

BACKGROUND

Students who experience ongoing failure in school face a myriad of difficulties in achieving long-term employment, and useful and fulfilling occupations. 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 provide a compelling case for the need to develop programs that improve numeracy outcomes for students who are performing at or below the National Literacy and Numeracy Benchmarks. There is a specific need for such programs to be effective for Indigenous and rural students and those with a language background other than English. In addition, national data identify a substantial systemic decline in both the number and percentage of students achieving Numeracy Benchmarks in Year 3, Year 5 and Year 7. This trend needs to be attended to as a matter of urgency. It is our contention that by the time these students reach Year 5 it is particularly difficult to bring about sustainable change within 'normal' classroom environments. Consequently, there is a need for educational researchers to design and investigate interventions that support students who experience these difficulties.

QuickSmart (Pegg, Graham, & Bellert, 2005) is an example of an evolutionary program of research that is having a strong impact with low-achieving students. The research program associated with *QuickSmart* is one of a few programmatic interventions conducted in Australian schools. The development and monitoring of the program has been supported by a number of different funding sources over the past seven years. Initially in 2001, the Commonwealth Government funded *QuickSmart* for one year under its innovative project scheme. Subsequently, the collection of follow-up data during 2002, 2003 and 2004 found that these students had maintained their performance improvements 24 months after they completed the intervention program.

Because of the very positive results of the initial *QuickSmart* program and the data indicating its continued effectiveness, an Australian Research Council Discovery grant by Pegg, Graham, and Royer (2003-2005), "Enhancing basic academic skills of low-achieving students: The role of automaticity in numeracy, reading and comprehension", allowed important aspects of the program to be researched and refined.

In 2006, with support from the federal Department of Education Science and Training and the Department of Transport and Regional Services, the program comprising two aspects was extended to 12 schools. The first aspect involved improving basic mathematics skill levels in11 top-end schools in the Northern Territory. A detailed analysis of the results indicated the effectiveness of the program. As a result the NT DEET is conducting a more intensive program in 2007 involving 20 schools. The second aspect concerned a disadvantaged rural school with large numbers of persistently low-achieving students (students below national benchmarks in numeracy and literacy). The program involved 87 students and constituted the largest single student cohort within a school to be involved in the *QuickSmart* program of research. Impressive gains in student performance during 2006 were evident that placed the school among the best in NSW in terms of value-added results for the Year 7–8 cohort.

PURPOSE OF *QUICKSMART*

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, and had been resistant to improvement despite attempts to overcome their learning problems. They were unable to draw benefits from other in-class and withdrawal instructional activities.

An additional purpose of the program is for classroom teachers, special needs support teachers and teacher aides (referred to below by the generic term 'teachers') to learn how to work with and significantly improve the learning outcomes in basic mathematics skills of underachieving students in the middle years of schooling. The program offers professional learning and 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.

THEORETICAL UNDERPINNINGS OF *QUICKSMART*

The *QuickSmart* assessment and intervention approach is an innovative instructional method informed by 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 places an emphasis on 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 mundane or routine tasks. In this way, students become better resourced to undertake higher-order mental processing and to develop age-appropriate basic mathematics (and literacy) skills.

There are theoretical and pragmatic reasons that support the importance of basic information retrieval to both basic mathematics (and literacy) skills. First, it is generally accepted that the cognitive capacity of humans is limited, i.e., working memory has specific constraints on the amount of information that can be processed (Anderson, 1983). As such, there is a strong theoretical basis upon which to expect that improving the processing speed of basic skills frees up capacity, which is then available for the cognitive processing of higher-order problem-solving tasks.

Research has already indicated that the ability to recall information quickly is often not subject to conscious control and, subsequently, uses minimal cognitive capacity (Ashcraft, Donely, Halas, & Vakali, 1992; Hanley, 2005; Zbrodoff & Logan, 1996). Another reason why automaticity in basic information retrieval is of prime importance is that it allows for small decreases in time to accrue in undertaking sub-tasks associated with a question, again freeing up working memory. Even small decreases in the time taken to process information in working memory during basic problem-solving situations can be significant. Thus speed of information retrieval plays an important role in determining the success or otherwise of students undertaking basic mathematics (and literacy) tasks.

THE *QUICKSMART* PROGRAM

In order to contextualise the importance and effectiveness of the *QuickSmart* program, it is necessary to describe the intervention in some detail. 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 paper and material resources, *QuickSmart* utilizes a Cognitive Aptitude Assessment System (CAAS) to support learning and to assist with 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 system is installed on a laptop computer and enables precise measurements of students' accuracy and information retrieval times on numeracy tasks. Importantly, the assessment tasks used are designed and sequenced in order to help identify particular obstacles that may impede student learning (Royer, 1996).

Specifically, when a stimulus is presented to a student who responds into the microphone, the system records vocalisation latency and a scorer pushes one of the two buttons on the computer to record the accuracy of the response. At the end of a task, the software computes a mean and a standard deviation for response latencies. Also, the software automatically cleans the data by eliminating, as outliers, responses two standard deviations from the mean, such as impossibly fast or unusually slow scores. When the student is finished, the percentage of correct responses, as well as the mean and standard deviation are immediately available and can be recorded and shared with the student. These data are also retained as part to assist in part in the analysis of change in students.

The professional development program accompanying *QuickSmart* is focused on supporting teachers to understand and provide:

- effective instruction that maximises student on-task time, and provides learning scaffolds to ensure students experience improvement and success;

- deliberate practice that is integral to every lesson, allows for success and is focused on providing targeted feedback to improve learning;
- guided and independent timed practice activities;
- strategy instruction and concept development;
- confidence to their students by encouraging a 'can do' attitude;
- appropriate teacher and peer modeling; and
- motivational academic activities that are opportunities for modelling and to develop 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 built about deliberate practice 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

Also teachers come to experience:

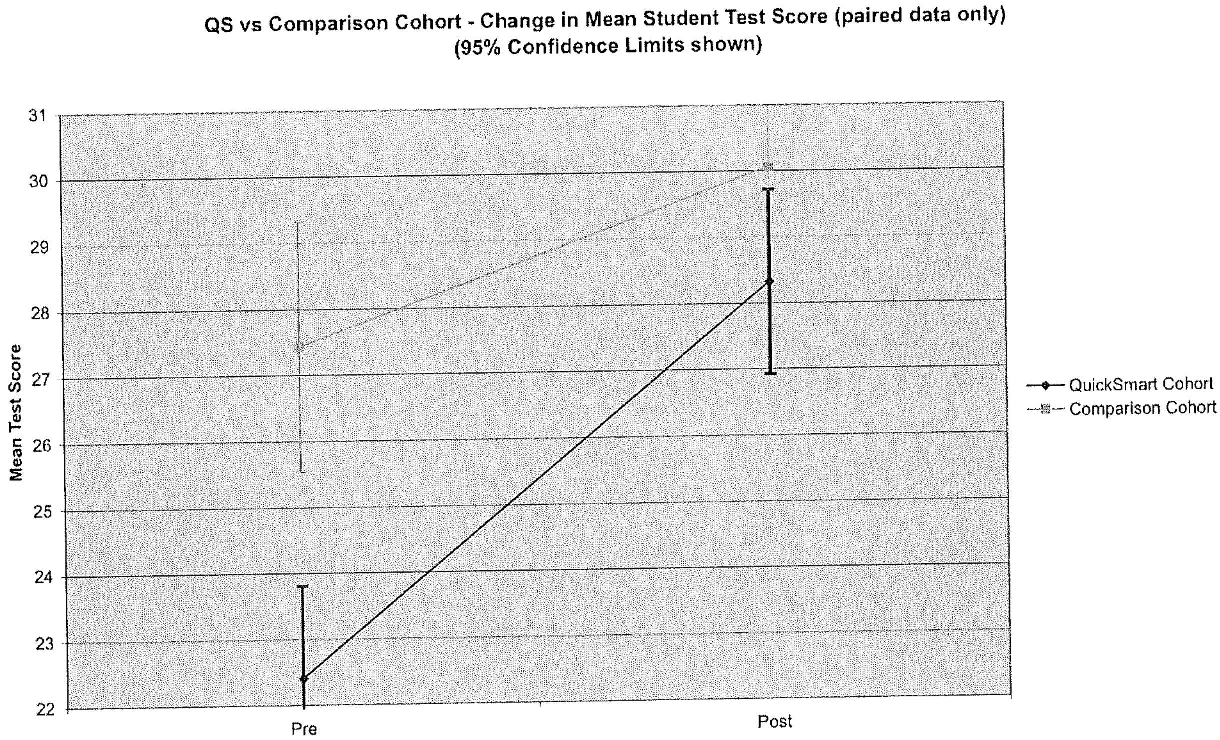
- how automaticity requires conceptual understanding and efficient, effective strategy use; and
- how assessment provides formative information relevant to the progress and design of each individual's program.

QUICKSMART RESULTS FROM 2006

In 2006, with Federal Government support the *QuickSmart* program was expanded and approximately 300 students undertook the program in the Northern Territory (NT) and New South Wales (NSW). In the NT 203 students were in the program and there were 111 comparison students. In NSW at Orara High School 87 Year 7 students, over 60% of the 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 John Bradbury, Curriculum Officer Numeracy, Teaching, Learning and Standards Division NT (2006) compares pre- and post-scores on a basic skills test for the *QuickSmart* cohort and groups of comparison students.

Northern Territory results on 2006 intervention



The graph illustrates the gains made by the *QuickSmart* group of students as compared to their average-achieving peers. The two cohorts were statistically significantly different at the start of the program from the comparison students and were not statistically different on the post-test.

In the case of Orara students attempted the State-wide Secondary Numeracy Assessment Program (SNAP) in Years 7 and 8. The results were summarized in an article written in a NSW DET by Cotton (p.5, 2006) in *Side-by-Side.* The first three paragraphs are reproduced below and report the gains made at Orara High School.

> It's not often that a school records a meteoric rise in student performance over a single year. So when Orara High School recorded the highest growth in its history for Year 8 literacy and numeracy, the principal, Graham Mosey, summed it up in three words: 'We were thrilled!'
>
> Last year almost half of the school's Year 7 cohort was under the national benchmark for literacy and numeracy. But in 2006, all of the students, now in Year 8, performed above the benchmarks – almost doubling the state average growth in their English Language and Literacy Assessment results, and more than doubling the state average growth in writing. Similar results were brought home for the Secondary Numeracy Assessment Program.

> 'Anecdotally, we'd been told things were really improving, but it was good to get some data that confirmed that was the case', Mr Mosey said.

Both sets of results point to how *QuickSmart* helped "narrow the gap". Analysis has identified impressive statistically significant gains that mirror the qualitative improvements reported by teachers and parents.

Finally, it is worth reporting on the parents' perceptions of the program in order to "bring to life" the results already presented. Parents were interviewed about how they felt their children reacted to the *QuickSmart* program. In all cases their views were positive. Examples of parent's comments are included below:

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: it 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 understanding of their learning.

Overall, *QuickSmart* has accrued an extensive evidence base covering several years showing that there is an alternative to failure for many middle-school students not meeting National Benchmarks. The program provides a fourth, and potentially last, phase intervention that will enable students to proceed satisfactorily with their studies for the remainder of their schooling. Many teachers who have been involved in the program believe that *QuickSmart* is their last realistic chance of being able to help low-achieving students in a sustained, and for students in a sustainable, way.

FOUR FEATURES OF LEARNING

This section reports on four features that have emerged from our observations of students and teachers within the *QuickSmart* program. These features – student characteristics, cognitive processing, deliberate practice, and feedback – are particularly relevant to the target group of low-achieving students in the middle years of schooling but are also relevant to other groups of students who are not reaching their learning potentials. At the basis of these four aspects lies the notion of developing within students the ability to "trust their head".

Student characteristics

Students who are persistently low achieving in mathematics exhibit a number of similar characteristics. They utilize inefficient and error-prone approaches to learning and recalling information. Effortful calculation of basic arithmetic facts precludes focus on procedures and problem solving. Often finger strategies dominate simple tasks and this compounds poor speed and accuracy with "the basics". Geary (2004), is but one of a growing group of researchers who, suggests that disruptions in the ability to retrieve basic facts from long-term memory might be considered a defining feature of mathematics learning disability.

These students also have learning gaps or misconceptions that impact on their class or test performance. This translates in performances below national benchmark figures. As a result they report not having a feeling of control over their learning. Compounding feelings of low self efficacy is the fact that by the time some students are in the middle years of schooling they have been targeted for support for many years in various forms without success. These students could be described as "treatment resistant". This is an unfortunate term but one that focuses attention on the grave plight and difficult-to-reverse situation in which these students find themselves.

This point highlights what research has been telling us that low-achievers in mathematics have considerable difficulty in developing automaticity in their number facts. However, if this situation is not addressed then the achievement 'gap' between these students and average achievers gets wider. Really students need to be able to be proficient or fluent in basic mathematics before the end of primary education when they are around 11 or 12 years of age. Any real chance of students developing number sense or forms of mathematical reasoning in secondary school depends on this occurring.

While poor self efficacy is prevalent these students can also be described as 'classwise'. This term (Pegg & Graham, 2007) is analogous to people being described as streetwise. It highlights how these students have become familiar with the ways of the classroom and how to "survive" within it. Characteristics of this form of student behaviour include the ability to have traces of learning and understanding become invisible to the teacher. For example, students may conceal their lack of basic skills through various behaviours like copying and denial so that neither the teacher nor peers are fully aware of their academic difficulties.

What features bring about change? The salient points related to *QuickSmart* instruction were addressed earlier, however, a few need to be emphasised. Students need *time* to acquire the desired skill and understanding level and time to establish new neural pathways. They need to be aware that during changes to cognitive functioning, particularly early in the process, people are extremely vulnerable as they let go of familiar routines and embrace new ones. Motivation is a key factor underpinning the will of the student to try again because they want to improve their performance and because they realize that simply doing what was unsuccessful before is not the best approach. Improvement requires a genuine cognitive reorganization of the processing underlying the skill needed. One catalyst *QuickSmart* uses to bring about this change is using time as a dimension of learning to build students' awareness of their progress and possibilities for improvement, i.e., through feedback and deliberate (systematic) practice that is targeted at particular goals that are achievable and understandable for the students such as between 35 to 40 flashcards correct in one minute.

Cognitive processing

There are three elements to this discussion of the role of cognitive processing in learning. The first is about the meaning and functioning of working memory, the second concerns the importance of automaticity, and the third discusses how these ideas are operationalised through the theoretical frame of the SOLO (Structure of the Observed Learning Outcome) model (Biggs & Collis, 1991; Pegg 2003).

Our view on mental activity is guided by Baddeley (1986) and his co-workers who introduced the notion of working memory. Working memory is defined as a processing resource of limited capacity involved in the preservation of information while simultaneously processing the same and/or other information (Baddeley & Logie, 1999). This differs from long-term memory in which procedural and declarative information is stored for long periods of time and short-term memory where small amounts of material are held passively and reproduced in an identical form to which they were encoded. Activation of short-term memory draws upon minimal resources in long-term memory.

Working memory is considered by Baddeley (1986) to have three components. These are a central executive system that interacts with two subsidiary storage systems: a speech-based phonological loop for storage of verbal information and a visual-spatial sketchpad that is involved in the generation and manipulation of mental images. The central executive system coordinates these two subsidiary systems, as well as activating information from the long-term memory. Swanson and Siegel (2001) stated that there is also a mental work space that has limited resources and has a combined processing and storage facility that is under the control of the central executive system and can operate in a distinct fashion from the two subsidiary systems.

We believe that difficulty with working memory capacity underlies many of the problems low-achieving students experience in acquiring mathematical competence or undertaking more difficult mathematics tasks. Hence, a critical step in supporting these students is to provide them with experiences that enable them to reduce the cognitive load of processing basic skills. Similarly, if we can support students to replace effortful (high cognitive load) strategies with more strategic and less demanding approaches then their performances in mathematics will improve. One approach to reducing cognitive load and hence free working memory space is to develop automatic responses in routine tasks.

It is our belief that automaticity in basic mathematics fact and skills is fundamental to a student being mathematically proficient and able to achieve success in higher mathematics. Hence, an important part of teaching is helping students reduce the cognitive load associated with basic and routine tasks to facilitate deeper mathematical experiences. There are large processing demands associated with inefficient methods and finger counting strategies, etc as opposed to direct retrieval approaches.

The SOLO model offers us a potential framework to consider when and how teaching might facilitate student development. In particular, SOLO can provide ideas on where direct teaching, explicit teaching, and drill and practice are more appropriate than indirect teaching where problem-solving inquiry and reflective discussion might be more useful.

The SOLO model posits that there is a learning cycle comprised of a focus on a single aspect (referred to as unistructural), followed by a focus on several independent aspects (referred to as multistructural) and subsequently a focus on the integration of the individual aspects (referred to as relational). This unistructural, multistructural and relational cycle repeats itself with the acquisition of new ideas and concepts as well as adapting to accommodate the growing abstraction of ideas.

QuickSmart is primarily focused on unistructural elements of learning where students are helped to understand separate individual aspects related to basic mathematical facts and then provided with an opportunity to focus directly on these specific aspects through deliberate practice. The purpose of focusing on these unistructural elements is to reduce working memory demands that, in turn, frees working memory resources and facilitates the development of multistructural thinking. At the multistructural level, students have sufficient working memory space to access several aspects separately and to undertake sequential procedures that do not require interconnections among the aspects to be utilized.

Hence, for both the unistructural and multistructural levels directed learning or explicit teaching is beneficial and required to help students come to know the individual elements needed and to practice and consolidate their understandings. Instruction that targets the integration of ideas and attempts to move students into the relational level is more about creating an environment for students to make the links themselves through their own motivation and understandings.

Deliberate practice

Practice in terms of repeating similar procedures or exercises has value in terms of establishing routines for certain activities and hence reducing cognitive load. However, in terms of moving students beyond their current state of performance, practice can actually limit what can be achieved in education. Most practice, even when engaged in over a long period of time leads to plateaus or ceilings in performance. The amount of practice, past a certain point, does not necessarily lead to ongoing improvement in performance. The reasons for this is that if students are to improve they must either think differently about situations or replace inefficient strategy use. To obtain improvement in performance there needs to be a cognitive reorganisation of the skill, which is accomplished through targeted practice activities. This is achieved by applying deliberate effort (or practice) to improve performance.

We use the term "deliberate practice" drawn from research that has explored and attempted to explain expert performance in a range of areas outside of education (Ericsson, Krampe, & Tesch-Romer, 1993). For us, deliberate practice within an education context takes four key positions. It

- is a highly structured activity that has been specifically designed to improve the current level of performance;
- allows for repeated experiences in which the individual can attend to critical aspects of tasks;
- involves specific tasks that are used to overcome weaknesses; and
- enables performance to be monitored carefully to provide feedback.

Students are motivated to exert effort to improve because focused practice improves their performance. Evidence of this improvement is available to all observers and to the students themselves. In *QuickSmart* deliberate practice takes the form of consistently-encountered, supported and timed tasks that are graduated in terms of difficulty and cognitive demands.

Feedback

Like practice, feedback is a complex feature of teaching and learning that is fundamental to improvements in student achievement. However, there are some features of feedback that make it particularly effective. We draw on the work of Hattie and his colleagues (e.g., Hattie & Timperley, 2007) to explore these ideas.

Feedback needs to be carefully defined and used thoughtfully as an integral part of instruction in order to engender student improvement. Hattie identified four levels of feedback.

1. Feedback about the self unrelated to performance on a task.
2. Feedback on self-regulation so that the student knows how to complete the task with less effort and more success.
3. Feedback aimed at how the task is completed. This includes feedback on strategic levels of understanding and how to process information required to complete the task.
4. Feedback about the task that allows students to acquire more, different, or improved information.

Hattie's argument is that these levels of feedback are least effective at the first level, powerful at the second and third levels in terms of deep processing and task mastery and most powerful at the fourth level when information is used to improve strategic processing.

With regards to *QuickSmart*, feedback is continuous - even relentless. It is our belief that without adequate feedback students will not automatically improve. We provide feedback in the form of praise when both the teacher and student can see that there are genuine improvements in understanding or performance. However, the majority of feedback is focused at a more strategic level. Feedback on activities completed as part of the *QuickSmart* program provides information to students on what they understand or do not understand, why the student is correct or incorrect, what needs to be changed or improved, and what information needs to be focused on or practiced in order to improve.

This form of feedback is linked to formative assessment practices, where the teacher uses assessment information to focus and guide teaching approaches. Formative assessment concerns finding out what the student understands and can do during the teaching/learning process as students are forming their ideas. It is this information, when shared with students that seems to have the greatest possible effect in terms of bringing about real change in student learning.

There are three further important characteristics of feedback. Firstly, feedback needs to provide information to the student on the substance of their performance and at the same time be supportive yet challenging to students. Secondly, feedback needs to be delivered in such a way that it sets a context that will move students on from their current performance to the attainment of improved performance. Thirdly, feedback is instrumental in allowing teachers and students to set realistic and attainable goals that are clearly-defined, shared and continually move students towards improved performance.

Within *QuickSmart* the process of effective feedback is facilitated because of the small class instruction mode of delivery that enables and expects the teacher to monitor and react quickly to students' approaches to tasks, their understandings and errors. Small class instruction provides a context for immediate feedback to students, while the consistent lesson structure of *QuickSmart* allows teachers the time and space to follow the performance of students through repeated trials (what we refer to as deliberate practice) over an extended period of time.

It is possible that one important reason for low-achieving students' poor performance is that in large class instructional settings these students have not been able to receive sufficient feedback on their performance to enable them to make the changes necessary to improve their performance in mathematics.

CONCLUSION

In short, the *QuickSmart* program represents an innovative direction for supporting both basic mathematics (and literacy) skills development. Our monitoring and evaluation of the *QuickSmart* instructional approach using quantitative and qualitative indications since 2001 have already established that this program significantly improves basic mathematical (and literacy) outcomes for educationally disadvantaged students (e.g., Graham, Bellert, Thomas, & Pegg, in press).

Approximately 800 students have been involved in the *QuickSmart* program since its inception in 2001. Without doubt, the focus of this work on changing the performances of low-achieving students is an important one in school education. It is also particularly important, in terms of intervention research, that findings are rigorously evaluated because the student population targeted in this work is among the most vulnerable in our education system (Dobson, 2001; Fuchs & Fuchs, 2005). It is obvious that educationally disadvantaged students should only participate in interventions that are accepted as educationally sound. Interventions based on unsubstantiated ideas have the potential to take up these students' valuable instructional time and result in little, or no, maintained gains in performance (Strain & Hoyson, 2000).

Central to the research and ideas reported in this paper is the belief that carefully obtained data collected over time are powerful in determining the robustness and utility of educational interventions. In the case of *QuickSmart* our research has provided additional insights concerning the role of working-memory and automaticity in information processing. It also has highlighted the need for further research.

This work is not easy. There are no quick fixes for students who have significant difficulties in Mathematics. For example, it takes considerable financial and human resources to run the *QuickSmart* program and it is difficult to obtain sufficient funds to provide a robust intervention to a sample population sufficiently large so that statistical procedures can be appropriately employed. The importance of control and comparison groups adds further to the cost and complexity of intervention research. However, such work must be pursued so that an important avenue of help for low-achieving students is not lost, but carefully explored and fully justified.

The benefits for students are immense. Programs such as *QuickSmar*t change students' lives in profound ways. They allow students who are consistently achieving poor results in their classrooms a chance to become active participants in the 'main game' of Mathematics. Students who have been involved in *QuickSmart* report that they:

- come to understand and are able to talk about their own learning as the program progresses;
- are able to establish goals and targets for their learning;
- begin to feel they can perform "just like the good kids"; and
- experience genuine improvement and success that encourages them to expend more effort to improve – they are motivated from within.

Most importantly students who have participated in *QuickSmart* begin to embody a new confidence in what they have learnt based on genuine observable improvements that are obvious to their peers, parents, teachers and themselves. As students gain confidence and become active contributors to their own Mathematics learning, they begin to succeed in ways that surprise them and that they can build on to achieve further classroom success. *QuickSmart* students report that they come to "Trust their heads" as effective learners of Mathematics.

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