The BASICS Intervention Mathematics Program for at-risk students

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Introduction

The “BASICS” or “Building Accuracy and Speed In Core Skills” Mathematics Intervention Program has been designed to enable students who are either low-achievers or have some form of learning disability, to attain real improvement and make the successful transition to core mathematics. The literature was reviewed to identify a collection of specific needs and deficiencies that these groups of students have historically exhibited in the mathematics classroom. Common issues identified through the review of the literature included the; use of inefficient and/or error-prone approaches; time-consuming mental computations; and a focus on simple mundane tasks in lieu of higher-order cognitive tasks (Bezuk & Cegelka, 1995; Pegg & Graham, 2007). The BASIC Intervention Program was designed to address these issues through a significant focus on improving the automaticity and accuracy of the recall of basic mathematical facts, rules, concepts and procedures. By improving automaticity and accuracy, we are negating the greatest impediments to increasing these students’ opportunity for success. Consequently, the purpose of the program is to reverse the cycle of continual low-academic performance for these students, at the same time, equipping them with the essential tools to gain success and achieve their potential in mathematics now and into the future. The ultimate aim is to increase the likelihood that these students can attain success in secondary mathematics, which will facilitate a more successful transition to post-school life. The structure of this program, its pedagogical strategies and assessment devices has been significantly influenced by the QuickSmart Program developed at the SiMERR National Centre at the University of New England.

Theoretical framework

The focus on both the accuracy and speed of recall of basic mathematical skills and concepts is designed to rectify the influential roadblocks to higher-order thinking, which are related to cognitive capacity and time (Graham, Pegg, Bellert & Thomas; Pegg & Graham, 2007). To start with, all students have a limited cognitive capacity, which means the amount of information that can be processed by their working memory is limited (Pegg & Graham, 2007). If a student's information retrieval skills and /or processing speed of sub-tasks are inefficient, their working memory reaches its cognitive limit. Consequently, this restricts their ability to progress through the task (Pegg & Graham, 2007). By increasing automaticity the time taken for a student to perform subtasks is decreased, which frees up their working memory. This enables students to move through the task with greater efficiency, ultimately reach a solution quicker and with more time and cognitive resources available to tackle higher-order tasks (Graham et al., 2004).

At-risk students

Students with learning disabilities or those with a history of low-achievement are the target group of this intervention project. Low-achieving students are typically students who: consistently achieve significantly low performance on standardised tests; perform poorly in in-class summative assessment; are placed in remedial mathematics classes; and have no formally assessed learning disability (Baker, Gersten & Lee, 2002). On the other hand, students who are classed as having a "learning disability" are derived from three broad categories, namely those students with: identifiable disabilities and impairments; learning difficulties not attributed to disabilities or impairments; and difficulties due to socio-economic, cultural, or linguistic disadvantage (Westwood, 2003). For the purpose of this project, when dealing with aspects directly related to both groups of students, they will be referred to as "at-risk students."

At-risk students who have difficulties in mathematics tend to use time-consuming, inefficient, and/or error prone strategies to solve simple calculations. In contrast, average-achieving students recall basic elements quickly and accurately (Pegg & Graham, 2007). At-risk students spend a greater proportion of the time on low-level tasks, to the detriment of the mathematical competence and the opportunity to engage in higher-order cognitive processes (Pegg & Graham, 2007). Consequently, the support mechanisms for at-risk students must provide them with the ability to reduce their cognitive processing load related to basic skills, through focused practice, continual reinforcement and the development of efficient strategies.

The aims

The short-term aims of the "Basics" Intervention Program are to improve the accuracy and recall of information retrieval time of simple mathematics concepts and skills for at-risk students. Pegg and Graham (2007) identify that an intervention program focused on improving the automaticity and accuracy of basic mathematical skills and concepts enables students to shift their focus from coping with mundane or routine tasks to engaging in higher-order mental processes. The longer term aims of this program are to enable at-risk students to engage in higher-order cognitive tasks with greater efficiency and success. Ultimately, at-risk students who participate in this program will have a greater chance of making a successful transition to core mathematics will break free of the perception "that they cannot do mathematics" and will be better equipped for post-school life.

Proposed model

The proposed model is based on a balance of strategies comprising: explicit teaching; specific questioning sequences; direct modelling of problem-solving skills; structured and guided problem-solving tasks; and diagnostic and formative task elements to assess understanding of targeted student learning. The model is designed also to cover the elements of the respective year level's work program. The model follows a pyramid structure (Figure 1), which emphasis three distinctive but sequential "levels" of instruction where each level is built upon the solid foundation of the previous level. The diagnostic and formative task elements are continuous and facilitated through the relevant year level section of the *Blackboard* learning management system. The pyramid structure is designed to give a representation of the proportion of time that each level should be allocated during each unit. The subsections that follow give a more detailed perspective, aims and teaching strategies of this proposed model.

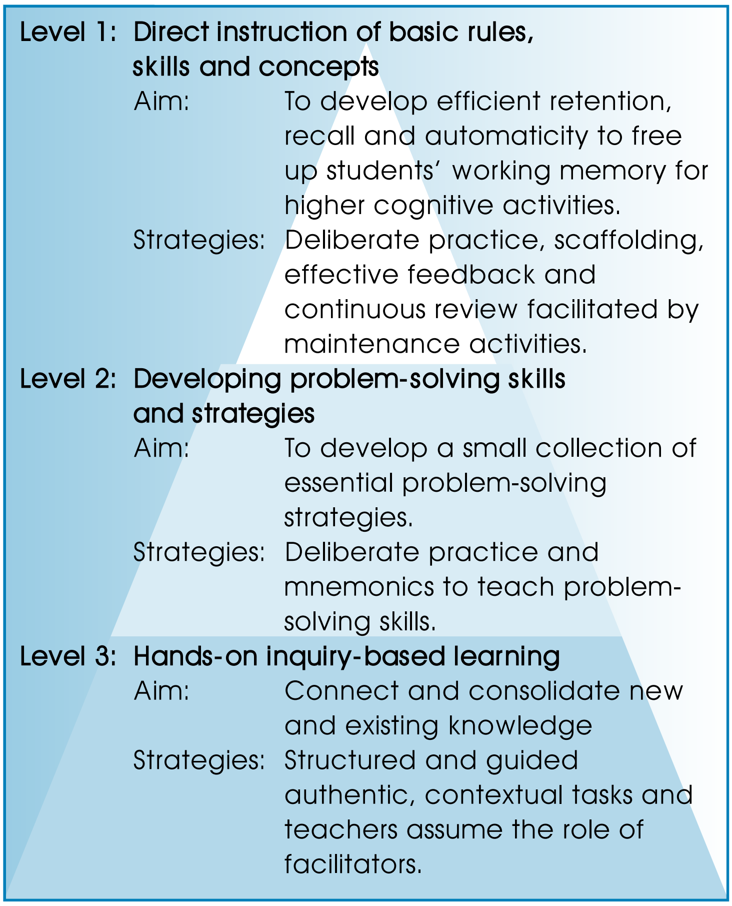

Figure 1. Proposed balance pyramid model of instruction for at-risk students.

Level 1: Direct instruction of basic rules, skills and concepts for efficient retention, recall and automaticity

This level encompasses the use of considerable direct instruction to develop meaningful retention, recall and automaticity of basic mathematics rules skills and concepts. The aim is for students to master basic rules, skills and concepts to develop a solid mathematical foundation and to free up their working memory for higher cognitive activities encompassed in Level 2 and 3 (Jones & Southern, 2003; McNamara & Scott, 2001). Teachers focus on utilising deliberate practice to model and consolidate rules, skills and concepts and provide support through effective feedback (Jones & Southern, 2003; Minskoff & Allsopp, 2003). Students must be able to retain learning and to recall stored knowledge if they are to apply concepts and skills, and acquire new ones (Bezuk & Cegelka, 1995). Consequently, teachers must continuously review previously covered material to increase retention and recall either at the start or conclusion of the class through short and concise maths maintenance activities (Minskoff & Allsopp, 2003).

Level 2: Developing problem-solving skills and strategies

The next level focuses the use of direct instruction and mnemonics to teach problem-solving skills (Greene, 1999). The success of students' problem-solving efforts is determined by the manner in which they approach mathematical problems (Bezuk & Cegelka, 1995). The aim is to develop a small collection of important problem-solving strategies, such as identifying the known and unknown information and the relationship between them; identification of the processes and steps required; and translating information into the right algorithm (Westwood, 2003). Also the aim is to instruct the students how to develop a plan to attack a problem and what procedures they need to use and when (Mercer, 1997). Critical elements for at-risk student success in problem-solving is the need for them to systematically identify the required procedures in order to improve their skills in selecting problem-solving strategies, and increase their efficiency in accurately implementing the relevant strategies and procedures (Bezuk & Cegelka, 1995).

Level 3: Hands-on inquiry- based learning in small groups

The final level is a culmination of the previous two and is built upon its foundation. The aim is to utilise hands-on structured and inquiry-based learning in small groups to enable students to connect and consolidate their newly acquired knowledge, to their existing conceptual framework and to apply their knowledge to authentic contexts (Anderson et al, 2004). Inquiry-based learning also provides at-risk students with the opportunity to learn how to make decisions and judgements among alternatives and improve their ability to hypothesise and infer (Bezuk & Cegelka, 1995). The role of the teacher is to monitor the group work and provide feedback and correct and challenge student responses. Structured inquiry should be implemented first. Structured inquiry is when the teacher directs students throughout the inquiry by giving them the problem, the procedures, and required materials, to enable them to formulate a pre-determined conclusion (Anderson et al, 2004). The rationale behind starting with structured inquiry is that it explicitly teaches students the necessary framework, procedures and possible strategies for solving a problem (Bezuk & Cegelka, 1995). The next stage is guided inquiry. This involves the teacher providing the necessary materials and problem statement to be investigated (Anderson et al, 2004). Students are asked to generate their own procedure in solving the problem.

Continuous diagnostic and formative assessment

A key element of this program is the use of continuous diagnostic and formative assessment. The continuous diagnostic and formative assessment elements will be designed and hierarchically organised along a continuum for each topic, to continually reinforce previous skills and concepts. The assessment and instruction will form a continuous cycle, as the assessment coupled with teacher observations will provide the basis of instructional design, delivery and individualisation.

The purpose of this assessment is to continually monitor both student accuracy and speed of recall as a means of increased automaticity, during the initial levels of the instruction model (Pegg & Graham, 2007). Student performance will be monitored through an individual "Performance Tracker". The aim of the Performance Tracker is for students to visually monitor a number of key facets of their progress through various graphical representations, in relation to a set of student-determined goals (Anderson, 2007; Martin, 2003). The rationale behind the use of these trackers is to enhance students' motivation and engagement in mathematics to ultimately assist in improving self-esteem and reinforce students' beliefs that they "can do" and achieve success in mathematics (Anderson, 2007; Martin, 2003).

Program components

The following is a brief outline and description of the key components of the "Basics" Intervention Program. The key components of the programs are:

- Pre-testing is utilised to identify what each student already knows and the specific gaps that exist within their prior knowledge and understanding. The information from pre-testing is used to tailor instruction and to address these gaps in each student's prior knowledge and understanding.
- The results of the pre-testing process are directly linked to the goal-setting of each student's "Performance Tracker" for that particular unit.
- The consistent use of timed formative assessment activities aimed at increasing the speed and proficiency of basic mathematical skills and concepts.
- The use of interactive learning objects, including online stopwatches and timers to assist students to 'externalise time' when completing in-class activities. These timers are used in conjunction with activities that utilise manipulative materials, flash cards, concrete objects and interactive pictures or diagrams (including Java Applets).
- Simple games and warm-up activities including Quick Reviews, Dominos, Bingo, Three in a Row, Same Sums Fast Facts.
- Small group work on simple problem-solving tasks.

Initial results

The first six months of the BASICS trial has been extremely successful, with the comments from participating teachers being very positive. The enthusiasm and professionalism of the teachers involved in the trial as been instrumental to its success, which is indicated by three key performance indicators. The first is the increased number of students making the transition from the trial classes to the core mathematics program. At this stage, nearly one quarter of the students, who began the year in one of the three participating classes, have made a successful transition to the core mathematics program. This is a significant increase in the movement of students to the core program compared to the same time last year. It is envisaged in the next three month period at least another ten students, based on their improved academic outcomes and self-belief, will move to core program. The second key performance indicator is the substantial increase in class averages, as compared to the previous year's data. In all three trial classes, the average has increased by at least 15% and is detailed in Table 1. The final performance indicator is the decrease in the number of students who failed to reach a satisfactory standard. At the same time last year thirty three students failed to reach a satisfactory standard. During the trial, this

Table 1. Comparison of class results prior to and during the BASICS trial.

	Class average prior to the BASICS trial	Class average during the BASICS trial	Improvement
Year 7 Support Class	50%	65%	+15%
Year 8 Support Class 1	38%	55%	+17%
Year 8 Support Class 2	34%	52%	+18%

number has decreased by one-third, with only eleven students failing to reach a satisfactory standard. It should be noted, that the trial classes have completed the same assessment tasks as the core classes, with only slight modifications on the basis of special consideration.

Conclusion

The "BASICS" Intervention Program is novel in its balance and integration of the optimal aspects of instruction from direct, constructivist and contextually-based instruction designed to meet the specific needs of at-risk students. The specific focus of this program is to address the memory and recall difficulties and inability to approach, structure and solve problem-solving tasks experienced by at-risk students. In addition, the use of continuous diagnostic and formative assessment will enable both teachers and students to develop positive relationships and improve student self-concept. The program's basis on a strong theoretical framework and excellent teacher uptake has produced significant improvement in student achievement and attitude to mathematics in all three trial classes. These results indicate that when provided with the right environment, at-risk students can achieve real success on work that is at comparable level of work undertaken in a core mathematics program.

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