

## SECTION 1 – RESEARCH PAPER

### A strategy for supporting students who have fallen behind in the learning of mathematics

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One of the consistent conclusions from international comparisons is that while Australian students overall are doing well, there is a long tail of underachievement (Thompson & Bortoli, 2007). This is no surprise to teachers of mathematics. A Year 9 mathematics teacher sent us the following story. He was revising some recent work, and the students were working on this problem:

You earn \$12 per hour for 22.5 hours. You pay 26% of your earnings in tax.

How much tax will you pay?

A girl, Emma, wanted help.

Mr T: Do you have a job?  
Emma: Yes  
Mr T: How much an hour do they pay you?  
Emma: I don't know I just started  
Mr T: Let's say you earn \$12 an hour and you work for 3 hours. How much is that?  
Emma: I don't know. Do you divide?  
Mr T: No. Think about earning \$12 an hour. You work one hour, and then another and then another. How much have you earned?  
Emma: I don't know  
Kylie (sitting nearby): Is it \$36?  
Mr T: Yes. Good.  
Emma (to Kylie): God, you're smart.

This story highlights a number of critical issues for mathematics education: How has this student survived so long in the system without action being taken to address her inability to answer such questions? What benefit is she gaining from her Year 9 mathematics classes?

It seems though that this is not an isolated case.

Consider the following two NAPLAN items taken from the 2009 Year 9 assessment in which students do not use a calculator. One item was presented as follows:

**Steven cuts his birthday cake into 8 equal slices. He eats 25% of the cake in whole slices. How many slices of cake are left?**

This was a “write in” answer and 85% of Victorian students did this correctly. Even though it is a very straightforward question, there were 15% who gave the wrong or no answer. Attributing difficulties to the reading does not explain the number who could not do it. All Year 9 work in mathematics would be much more difficult than this question.

Another item was as follows

**A copier prints 1200 leaflets. One-third of the leaflets are on yellow paper and the rest are on blue paper. There are smudges on 5% of the blue leaflets. How many blue leaflets have smudges?**

The students could choose from four options: 40; 60; 400; 800. There were 59% of the Victorian students who chose the correct answer. Recognising that this item involves three steps, after reading the question, there are 40% who could not choose the correct response from the four options. We suspect that they would have substantial difficulty in comprehending most of their Year 9 mathematics. We also suspect that their difficulties started well before that stage.

Given the diversity of achievement in most classes and the other pressures on teachers, it seems unrealistic to assume that class teachers, as part of their everyday teaching, can provide whatever support is needed by students who have fallen a long way behind. The following is a report of a specific initiative aimed to investigate the potential of an out of class student support intervention, the goal of which is to prepare students for the mathematics lessons they will experience subsequent to the support.

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### THEORETICAL FRAMEWORK

One aspect of the rationale for this approach is derived from cognitive load theory (Bransford, Brown, & Cocking, 1999). Pegg (2010), for example, outlined his perspective on maximising learning based on this perspective. The theory suggests that all information is processed in working memory and then stored in long term memory. The idea is to have the information that is stored in long term memory efficiently chunked so that it can be readily retrieved. The initial processing of information and preparation for this chunking happens in working memory, which is of limited capacity.

While Pegg (2010) focused on developing fluency in calculation as a way of reducing the load on working memory, this intervention program focuses on the ways that students attend to stimuli around them and the key information that they select for processing. In all situations, and especially in classrooms, there is more happening than we can effectively attend to, so it is necessary to select from among the sensory experiences.

Students who have fallen behind have greater difficulty in selecting the appropriate information and so the instruction, the task, the language, and even what the other students are saying and doing, becomes confusing. The hypothesis is that if the attention of such students can be focused on key information, they can select more appropriately what is likely to help them learn. An example of the way this works is in mathematical language. If students do not know what is meant by terms such as parallel, right angle, index, remainder, average, then the instruction using those terms will be confusing and ineffective since so much of their working memory will be utilised trying to seek clues for the meaning of the relevant terminology.

Without necessarily drawing on this particular theory, many educators based their approaches to instruction on the same principles. Tzur (2008), for example, argued that instruction should begin with what the students already know and are confident with and then move to content that is unfamiliar, rather than what he claims is the common approach of starting with unfamiliar content.

A second rationale for this approach is that classrooms are social and that, despite appearance to the contrary, all students would prefer to participate positively thereby satisfying a need for social connectedness (see Hannula, 2004) rather than avoiding the opportunities to participate (see Elliot, 1999).

### APPROACHES TO SUPPORTING STUDENTS EXPERIENCING DIFFICULTY

There are a number of existing programs designed to support students who have fallen behind in their learning. Gervasoni (2004) for example, argued that low achieving students can lose confidence in their ability and develop poor attitudes to learning and to school. One outcome is that the gap grows between the knowledge of these children and of other children and that the typical learning experiences provided by the classroom teacher for the class do not enable each child to participate fully and benefit. Ginsburg (1997) concluded that “as mathematics becomes more complex, children with mathematics learning difficulties experience increasing amounts of failure, become increasingly confused, and lose whatever interest and motivation they started out with” (p. 26). Gervasoni (2004) outlined the Extending Mathematical Understanding (EMU) program which involves structured learning experiences for teachers along with dedicated time in small groups with students experiencing difficulties. Gervasoni presented evidence that all students who experience this structured intervention improve.

Programs such as this are clearly successful in what they seek to achieve and this particular initiative is seeking to extend these in a particular direction.

It is interesting to consider the way that difficulties arise for teachers and students in common approaches to teaching and assessment. It is common, for example, for teachers to teach topic 1, then assess that learning and identify those students who did not learn the necessary content.

They then teach topic 2 to their class and try to reteach the topic 1 content to those who did not learn it. Either that or they ignore the weaknesses and hope the students can start fresh on the new topic. This not only makes topic 2 confusing but most likely increases the cognitive load on such students and increases their workload as well.

An alternative approach would be for teachers to assess readiness for topic 1 and support students who need it, either as part of the teaching of the topic or with additional support. They then assess learning on topic 1 and assess readiness for topic 2 before teaching that topic, allowing them to adjust their teaching as necessary.

# G.R.I.N. Intervention Program

While there are clearly responsibilities for class teachers in this, the following is a report of one approach to providing the necessary additional support.

## THE INTERVENTION

The intervention reported below was initially supported by the Wyndham Network of Schools in the Western Metropolitan Region of Melbourne. The participating schools agreed to release tutors to work with selected students in small groups, with the goal of providing preliminary information on the upcoming topic to those students, prior to their participation in the classroom mathematics lesson.

Initially the tutors met with the second author on three occasions to consider appropriate models for working with students in the tutoring sessions. The advice offered to the tutors was that they should:

- highlight and familiarise students with the vocabulary of their next mathematics lesson;
- use questioning to focus the students' attention on the relevant concept(s) and to 'resurrect' any prior knowledge of the concept that the students may have; and
- briefly model the sorts of activities to be undertaken in the next classroom lesson.

It is emphasised to tutors that they should not seek to teach the content of the subsequent lesson. The reason is that the goal is that the students prepare to learn in the lesson, as distinct from removing the need for them to concentrate when they get to the lesson.

Year 3 students were selected for inclusion in the program on the basis of the annual teacher judgement data, Early Years interview results and 'On-demand' testing data. Year 8 students were chosen on the basis of their NAPLAN results from the previous year. Students appearing above the bottom 20% of the applicable data were eligible for selection to the program. Where this number proved too many, the tutors conferred with the classroom teachers to select from the identified cohort, those students who it was believed would most benefit from inclusion in the program.

## THE DATA COLLECTION

There are three types of data presented: the first and major section uses the words of participants to elaborate details of the intervention; the second section is a brief

description of insights from a videotape record of a tutoring session; and the third section is some analysis of pre-and post assessments including comparisons of the results of those who were tutored and those who were not.

## FROM THE PARTICIPANTS

As a preliminary evaluation of the initiative, participants were interviewed at the end of the first phase, some six months after commencement of the project. In particular the interviews were intended to explore:

**What are the organisation and administrative challenges in implementing this initiative?**

**What was the experience of the tutors, the class teachers and the participating students?**

Sixteen people were interviewed at the end of phase one: three tutors (one from each school, designated as Schools A, B and C); six teachers (four from School A, and one each from Schools B and C); and seven students (five from School A and two from School B).

The following presents selected representative responses on aspects of the initiative.

### AIM OF THE INTERVENTION PROGRAM

One of the interview questions sought participants' perspectives on the aims of the intervention. The aim of the program being implemented before mathematics lessons was to give students "pre-knowledge" based on relevant language, according to two tutors and one teacher.

Particular comments were:

**What my hope is, is that I'm giving them the pre-knowledge, so front-loading the kids, so when they actually go to the numeracy lesson ahead they will have an idea of what is going to happen. In that way, that will free up some learning space so they're not still behind the eight ball. So they come in, they know what's expected and then they can gain more out of the numeracy lesson than they normally would have. (Tutor, School C)**

**Well, I think basically the whole idea was to immerse the kids in the language and then I guess they go back into their classrooms with some prior knowledge which is going to help them in their maths class. So if it's confidence, if it's knowing the language, understanding it, those sort of things. That's the big aim and I guess overall to increase their numeracy results**

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with a one on one situation. (Tutor, School C)

To improve their results, definitely, and just to improve their vocab and their knowledge. Before when I tried to do the lesson it would just go over their heads. They weren't able to make that connection where I feel that the two in the group can now make the connection and use it when they come into our classroom. (Teacher, School C)

It seems that their perspective on the aims and intention of the initiative were aligned with the goals of the program.

### BENEFITS OF THE PROGRAM

The interviews also sought insights into what the respondents saw as the benefits of the program. One tutor discussed the benefits to the students with regard to how they think about their learning.

So now they [the students] see the benefit and they are actually starting to think about what it is they are doing in their learning, and they are starting to know what sort of questions to ask if they're still unsure of what I've told them in that little session. (Tutor, School B)

She continued how students gained from the intervention program.

I can see the benefits to being one step ahead rather than always being on the back foot trying to continuously catch up. I think it's a benefit even if it's just seeing the main word and then that's a word that they're familiar with so when they go into the grade they say "Oh, I remember that word, I know what it is." And that's what I'm actually finding when I go back to revisiting. "Do you remember yesterday when we talked about this – can you tell me about it?" So it's going back so we can go forward, making constant connections. It's actually helped me hone in my teaching skills and then I'm relaying it back on to the teachers to say "We need to work on this". Because it's just the three of us we need to focus on what they're actually doing, instead of with 20 kids. So I can say "Look they really do not understand this. This is what they need". So it almost helps the teacher to be better prepared for the lesson. (Tutor, School B)

### STUDENT CONFIDENCE

One of the consistent messages from the teachers was that they found that students gained in confidence when they came back to the classroom.

I think it's because they feel more confident about the topic we're learning about because they've already had a bit of work

with [the tutor], so I think that helps them a lot. It's sort of a confidence thing where they can participate and they're willing to participate in discussions. (Teacher, School B)

Definitely. Confidence. Before if I was questioning them they would never put their hand up where as their hands are up straight away trying to tell me what they've been learning with [the tutor]. They want to tell me everything they've been learning. They do have a greater confidence to be put into a discussion, so it gives them the confidence to contribute in the class where before they would just sit on the floor, not really put their hand up, but now I can see the connection between working with [the tutor] and when they come in here. They are familiar with the words, they are familiar with the vocab and different areas like that. (Teacher, School C)

Huge change. Change in their confidence. There's about six kids from my room who come back and are just calling out. There is one particular child, he was really quiet, really reserved and when he started doing this with [the tutor] she said "It's hard to get a word out of him" but now he's coming back and sharing in front of the whole class. He knows beforehand what we are going to be doing. I've noticed a lot of changes in their confidence. Having already had a go at it and knowing they are coming back to do it in the classroom, and they know the answers and they know the language and I suppose that's why they're calling out and wanting to contribute more. (Teacher, School A)

While confidence is not the end goal, it is clearly advantageous and is likely to lay the foundation for changed approaches to participation.

### TRANSFORMATION

Building on the development of students' confidence, there were two stories in particular that illustrate the ways that the intervention seems to transform the experience of some students when they returned to their class.

My thought was that we are targeting those students that just need that extra bit to give them that shove and the biggest thing I've noticed is their confidence. They are coming back in and these kids are putting up their hand and they are getting the answer right. I do a lot of language in mathematics before I start anything, so the constant reinforcement, they are not just hearing it from me, they are hearing it from [the tutor] as well and that has made the biggest difference. I got so excited yesterday because one student who is part of the program has come from being so quiet – she doesn't like to speak a lot, she's almost mute and ESL and she now puts her hand up for everything. And I taught her long division yesterday – and

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she did it! It took two days, but long division, who does that in Grade 3? And she got it – I was so, so excited, I instantly emailed [the tutor], and said “You’re not going to believe this!” And another child in my class in the program, he is now so positive. I say “Maths” and he goes “Yeah, I’ve done this with [the tutor], and he gets so excited because he knows what he’s doing. I think it’s ace. (Teacher, School A)

So what I’ve noticed with a couple of students in particular is the increase in confidence and the willingness to have a go and actually talk in class now – which is what we didn’t have before. It used to be “I don’t understand” and you’d have to find them hiding underneath a cushion to pull them out to work with them. Whereas now, they want to work, they want to share with the others and they want to talk in front of class. (Teacher, School A)

These comments are very powerful and indicate the potential of this approach in transforming willingness of students to participate in class.

## IMPACT ON CLASS TEACHING

A somewhat unexpected outcome was the way that the program seemed to impact on classroom teaching. The following are comments by two of the teachers:

Yes. Even with my own teaching – I’ve been able to keep the lessons flowing rather than having to stop and start. This way it’s been easier to go through all the topics. (Teacher, School A)

It’s benefited my kids dramatically, but I don’t know whether it’s just my kids and the fact I’ve taken it on so completely – that might have been what’s made the difference. (Teacher, School A)

It is interesting that this should happen, and perhaps might be one of the major benefits of this approach to intervention over others, in that it potentially improves the learning of all students.

## RESPONSES FROM STUDENTS

Participating students were also interviewed and the following are some representative comments:

[The tutor] helps me know maths very well and it’s very fun to do maths... She teaches me how to skip numbers and it’s easier for me to skip numbers so I don’t have to count by ones [for subtraction]. (Student, School B)

[The tutor] helps me practice my writing. She’s helped with multiplication and ladders and vertical. She has helped me with division because we’ve been doing that (in class). (Student, School B)

It made it easier. ‘Cos first I didn’t know it [division] and then with (the tutor). I learnt something. (Student, School A)

It helps me do maths. It helps because I know what to do. (Student, School A)

Because you get to learn how to do them and also sometimes I get confused about it. She explains things and tells us to do them in our scrap books. (Student, School A)

It is because then I can understand and I know what to do. I always answer questions. (Student, School A)

The students clearly feel that they have learned, and see the connection to class participation.

## POSSIBLE NEGATIVE PERCEPTIONS FROM PARTICIPATION IN THE INITIATIVE

The interview sought to determine whether there were negative ramifications from participation in the program. This seemed not to have been the case as evidenced by the following comments:

I wondered how that would go in the beginning as well. Perhaps when they come back in the other students see them as confident rather than seeing them as being different. The other kids say “How come I can’t go with [the tutor] too?” (Tutor, School A)

No. Because there are so many kids coming and going for all sorts of things, we also have an ICT program happening, so they probably don’t really look at it like that or think that it is an extra catch up. They just come back and they have this extra knowledge and no one thinks anything of it. So it’s a positive thing. (Teacher, School A)

No. If anything more kids want to go and work with [the tutor], because they see it as a maths group who go off and do stuff and especially when they’ve achieved success they come back in and know about the work. So some of the other kids ask to be able to go as well. (Teacher, School A)

We also asked the students why they think they were chosen to participate.

So I can get more and more help. (Student, School A)

Maybe because I’m good at maths and maybe because I’m a little bit smart. (Student, School A)

I think because my teacher wants me to understand the work and we won’t become confused. (Student, School A)

Any concerns that we may have had about possible negative impacts appear to have been misplaced.

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### SUGGESTIONS FOR IMPROVING THE PROGRAM

We had asked whether there were suggestions for improvement. The following comments are representative of the responses, both of which seemed to be seeking a wider application for students at a particular grade level or for the whole school.

I think all students would benefit. There are even some Grade 4s who I have that would really benefit from this. (Teacher, School A)

The only frustrating thing is that you go into other year levels and I think “Oh, that kid could benefit so much with a bit of tutoring”, so it would be great to have it from levels P to 6 in primary. Because I know we’ve got some Grade 4s that are a lot lower than our Grade 3s. (Tutor, School C)

It seems they want more of the same.

### SOME IMPORTANT CONSIDERATIONS / ISSUES THAT EVOLVED DURING THE PILOT

There were a number of organisational considerations that became apparent during the trials.

**Group size:** Initially the tutors worked with groups of varying sizes however over time it became apparent that the optimum group size was three students. A common characteristic of the selected students was a lack of confidence when working in numeracy and this manifested itself as a reluctance to ask and/or answer questions, to offer suggestions or take risks during the sessions. It became apparent that the more students in the group, the greater the opportunity for each student to continue these practices. At the same time, the tutors could recognise a real benefit in having at least two students per group because this provided opportunity for students to discuss the mathematics in a familiar way, share strategies, support each other to take risks and finally to remind and prompt each other during their whole-class mathematics lessons.

The tutors gradually all reduced their groups to either two or three students. Careful attention was paid to the mix of students in each group to avoid personality clashes. Similarly each group comprised students from the same class to ensure they would be able to support each other back in the classroom. Some tutors opted for groups of 3 to accommodate the frequent absenteeism that appears to be linked to low achievement, particularly in the secondary school setting. A group of three students meant that even if one student was absent, the remaining

two students could have worthwhile dialogue during the session.

**Absenteeism:** While mentioning absenteeism it is also worth noting that initially, in the case that a student was absent, some classroom teachers substituted other students into the tutoring session to ‘fill the gap’. As it happens, this upset the balance of the sessions and became a source of frustration to the tutors. The short sharp timing of the session became lost when the model needed to be explained to the non-tutoring student, the reflection on past lesson success/challenges was difficult, the confidence of the tutored student sometimes regressed and the relationship between tutored student and tutor became difficult. It was therefore decided that in the case of an absenteeism non-G.R.I.N. students would not be substituted into the G.R.I.N. session.

**Withdrawal from class:** It is important that students are not withdrawn from the same lesson repeatedly. Students with low confidence in numeracy may demonstrate confidence in other fields and should be given an opportunity to demonstrate this where possible. Therefore tutors spread the lessons from which a student was withdrawn across a range of subjects on different days and at different times during the week.

**Adequate time for tutors and teachers to meet:** It was an ongoing challenge for tutors and teachers to meet regularly to share information about future lessons and discuss student progress. Some tutors were also classroom teachers and had ready access to team planning sessions, while others were forced to rely on teachers’ work programs, casual conversations in the staff room or chats on the run in corridors.

**Professional learning of tutors:** All tutors met together on a monthly basis for the purposes of sharing ideas and professional learning. During these sessions the structure of the tutoring sessions was re-visited and refined as required and common tools for data collection were developed. Tutors also participated in professional development about effective questioning and ‘wait time’. Over time the tutors worked as a professional learning team and gave feedback to each other on the basis of video clips that they have taken of themselves delivering tutoring sessions. These video clips became a powerful tool for focusing on the structure of the intervention model, the purpose for each section of the structure and the tutor’s role within that structure.

## LESSONS FROM VIDEO RECORDS

One of the video records shows three Year 8 boys participating in a tutoring session. The boys start the session very restless, paying little attention to the task, and potentially threatening order even in the small group. The tutor on the video progressively engages the students in reviewing what they know about the topic, and clarifying any language issues that may have been relevant.

The tutor also models the action expected in the class, which was using a protractor and compass. The boys became progressively more engaged in the task, and at the end were fully engaged in listening and watching. Subsequent reports indicate that the students returned to their class and participated well and appropriately in the full class learning experience.

The inference is that an outcome of the tutoring is that students are more able to participate in the social

experience that is the classroom. Another insight is that allowing such students to watch, as distinct from merely listening may be a potentially useful strategy in both tutoring and whole class sessions.

## SOME COMPARISONS OF ASSESSMENT SCORES

All schools used a form of assessment at the start of the year and then again near the end of Term 3, using VCAA on demand testing. The schools were quite different in the way that the results were recorded, so they are presented separately.

Table 1 presents the results for the four primary schools that participated. The scores relate to the VELS levels. Notionally each year students should improve 0.5 of a level. In each case the gains in the means of the tutored students are compared with the students who did not participate in the tutoring.

Table 1. Comparison of gains of tutoring for tutored and non-tutored Year 3 students

Name	Tutored students (n)	Not tutored students (n)
PS A	.44 (12)	.30 (12)
PS B	.40 (12)	.32 (26)
PS C	.38 (22)	.40 (81)
PS D	.30 (11)	.50 (55)

In two primary schools the tutored students improved more than the others, and in two schools the reverse is the case. Therefore it is not possible to make judgments about effectiveness for tutored students from these data. It is noted though that the assessments measured knowledge over broader content than would be covered by the tutoring program, indicating that any learning of students being tutored seemed to apply beyond those topics taught.

Table 2 presents results for Year 8 students in two secondary schools.

Table 2. Comparison of gains of tutoring for tutored and non-tutored Year 8 students in two schools

School	Group	N	Mean gain	Median gain
SC A (N=168)	Tutored	24	.45	.55
	Not tutored	144	-0.03	.08
SC B (N=111)	Tutored	21	.48	.50
	Not tutored	90	.29	.40

In both cases, the gains for the tutored students were greater than for the not tutored students, and in one case much greater. Again, given that the comparison is on more than the taught topics, this improvement is outstanding.

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### CONCLUSION

It is reasonable to conclude that the intervention was extraordinarily successful. The tutoring initiative has a clear rationale, it was received positively by students, tutors, and class teachers, and there is evidence of positive broader learning gains from the students.

There are two important aspects to the initiative. First, participation in the tutoring does indeed prepare students to be able to participate in their usual classes by reducing their cognitive load in the class. Second, since learning and classrooms are social settings, it allows tutored students to participate normally in the social settings thereby changing the way that they see themselves.

It is noted that there are other advantages in this approach. The resources required are not much greater than the cost of providing the tutor. There is a need for teachers to plan effectively and to articulate their plans to the tutors. There is a need for close collaboration between teachers and tutors. While there is some requirement of education of tutors and teachers, these are minimal and the whole process is readily sustainable. There are multiple stories of transformational change in the behaviour of some students. The approach clearly has potential.

There is one further issue. Sometimes commentators suggest that some students cannot learn mathematics whatever we do. This project demonstrates that this is a false assumption and that students can learn if given appropriate opportunity.

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