Sustainable improvements in student mathematics learning and disposition as a result of *Prepare 2 Learn* intervention

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This paper reports on a mathematics intervention initiative, *Prepare 2 Learn*, designed taking into account research literature and elements of other successful programs. The program was intended to prepare students for their upcoming mainstream mathematics lessons as well as make them aware of the impact they can have on their own learning through their actions and attitudes. The intervention resulted in the students reaching the expected standard or beyond for their year level as well as positively changing the way they saw themselves as mathematics learners. The following paper focuses on sustainable changes to one students' mathematics learning and disposition.

Introduction

"Students struggling with mathematics may benefit from early interventions aimed at improving their mathematics ability and ultimately prevent subsequent failure" (Gersten, Beckmann, Clarke, Foegen, Marsh, Star & Bradley, p.1, 2009). As an education system we are continually trying to find ways to help students not reaching expected levels. We do this because we suspect that without targeted help the most likely scenario is that these students will fall further behind their peers in mathematics (Sullivan & Gunningham, 2011). The research reported here was intended to provide an intervention that would focus on supporting students approximately six months behind their year level to reach expected level or beyond, as well as positively changing the students' mathematics disposition. The program, *Prepare 2 Learn*, did this by preparing the students for their mainstream lessons as well as increasing students' awareness of the impact they can have on their own learning. The program was based around four main elements, which were chosen after investigating the research literature and successful intervention programs. It was hoped that the collection of components, which made up the *Prepare 2 Learn* program, would assist students to reach the expected class standard as well as give them the necessary skills to maintain this improvement throughout their future mathematics education. The longevity of the impact of the initiative was as much a focus as the immediate expected success. This paper briefly explains the components of the program and why they were chosen, the two phases of the intervention, the results of phase 1 on the students learning and their attitudes towards learning, two years after the completion of the program. The results support the proposition that *Prepare 2 Learn* is an intervention that can show positive sustainable improvements in students' mathematics learning and disposition.

Identifying key components of current intervention programs

The *Prepare 2 Learn* program was designed after taking into account research findings around intervention programs. To do this, effective intervention programs were studied to establish key components that would enable students who had fallen behind their peers to achieve. The collection of components needed to assist the students in the short term to make up the necessary ground to be at or above the expected class mathematics level as well as positively changing the way the students saw themselves as mathematics learners.

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The four key components selected were: building prior knowledge of language, concepts and skills to prepare students for their subsequent mainstream mathematics lessons; increasing fluency with basic number facts; encouraging a growth mindset; and developing responsible learning behaviours, through metacognitive strategies.

The first component, building prior knowledge of language, concepts and skills to prepare students for their mainstream mathematics lessons, was considered an essential element. As Bransford, Brown and Cocking (2003) explained, "All new learning involves transfer based on previous learning and this fact has important implications for the design of instruction that helps students learn" (p.3). Similarly, Sullivan and Gunningham (2011) used this premise to plan the GRIN intervention sessions to cover the necessary prior knowledge the students would need to allow them to access their mainstream mathematics lessons. Without such assistance, Sullivan and Gunningham (2011) argued that many low achieving students would not be able to construct new knowledge and understanding from learning experiences in their classroom. This is due to the cognitive load theory (Bransford et al., 1999), which stresses that working memory has limited capacity. As such, students who lack the necessary prior knowledge, for example, in a domain of mathematics, often use some of their working memory to try and understand this prior knowledge, as well as attempting to understand the new concepts being introduced. This added aspect, often causes the working memory to become overloaded.

The GRIN program also highlighted classrooms as social settings, where human beings show a need for social connectedness, suggesting that prior knowledge contributed to confidence and participation (Sullivan & Gunningham, 2011). Sullivan and Gunningham argued that preparing students for their upcoming mainstream mathematics lessons would allow these students to enter the classroom feeling confident and more willing to participate in classroom learning experiences. Middleton and Jansen (2011) also supported this notion arguing "fitting in really matters both intellectually and socially" (p.9) for students. This element, teaching prior knowledge, was designed to address both aspects.

The second component of *Prepare 2 Learn* was increasing fluency with basic facts. The *Quicksmart* program had shown the benefits of intervention sessions that focused on practising foundational number facts in improving students overall mathematics results (Graham, Bellert, Thomas & Pegg, 2007). Improvement in these basic facts was also expected to lessen cognitive load on the working memory, freeing up capacity to attend to learning new mathematical concepts. As well, it was anticipated that better fluency would increase student confidence and so encourage them to participate and engage more fully in classroom activities, thus supporting the students' need for social connectedness.

The third component was encouraging a growth mindset. Dweck's (2008) research revealed that people generally hold one of two mindsets: a "fixed mindset"; or a "growth mindset". People with a "fixed mindset" believe their "…qualities are carved in stone" (Dweck, 2008, p.6) and there is little one can do to improve their knowledge or abilities. However people with a "growth mindset" see hard work and deliberate practice as vehicles to self-improvement. The *Prepare 2 Learn* initiative aimed to encourage in students an understanding that their actions could impact their learning potential.

The last component of the *Prepare 2 Learn* program was the need to develop metacognitive strategies in students. Hattie (2012) explained that "…self-regulation, or meta-cognitive, skills are one of the ultimate goals of all learning…" (p.102). Caswell and Nisbett (2005) initiated a study designed to enhance mathematical understanding through self-assessment and self-regulation of learning. It aimed at making students conscious of actions that they could initiate to improve their learning. The researcher anticipated this

component would be vital to the students being able to sustain their improvement of mathematics into the future.

To summarise, the *Prepare 2 Learn* initiative attempted to enable students falling approximately six months behind their peers to reach the class standard or above as well as give them the necessary learning skills to achieve into the future. To do this it would provide relevant prior knowledge, build fluency of basic facts, encourage a growth mindset and teach metacognitive strategies.

The Research Context

Prepare 2 Learn was a research initiative that consisted of two phases. Phase 1 comprised three year 6 students and Phase 2, four year 3 students. Both phases consisted of students who were considered to be approximately 6 months behind the mathematics standard expected for their year level. The students were selected taking into consideration matters like, regular school attendance, permission from parents and participants, and participation in other programs.

The intervention sessions were planned by me, taking into account the lessons to be taught in the mainstream classrooms each week. As the mathematics leader in the school, I was part of year level mathematics planning and so was aware of the concepts that would be taught in the classrooms. These tutorials sessions were in addition to the mainstream mathematics lessons.

Before beginning the program the students watched videos on the brain. They then discussed as a group the impact of practice on the brain's ability to retain information long term. From these videos and discussions, the students developed a checklist of actions of "good learners". The checklist was pasted into the students' mathematics books and for 3 weeks was filled in by the students at the end of each of the mainstream mathematics lessons. This checklist was designed to help the students evaluate their learning actions and continually prompt them about the types of actions good learners regularly show.

The program ran for 15 weeks with the students attending three 40 minutes sessions per week. The structure of the tutorial sessions were as follows:

5 minutes: Mental computation activities based on the intended topic

5 minutes: Looking at the self-reflection checklist. Teacher and students look at the students' checklists, discussing how to be an effective learner using metacognitive strategies.

25 minutes: Teacher establishes what prior knowledge the students actually have and then introduce the necessary mathematical language, concepts, basic skills etc. through mathematics activities

5 minutes: Summary - students to reflect on what they will need to know to be able to engage in the follow-up mainstream lesson

At the conclusion of the program, data were collected from myself, being the intervention teacher, class teacher, students and their parents, to ascertain the program's success.

Instruments

The methodology informing the data presented below, included elements of action, design and case study research, and used a mixture of both quantitative and qualitative data. Before the program began the students were given a PAT Mathematics Test (Progressive Achievement Test) (Lindsey, Stephanou, Urbach, & Sadler, 2009). This standardised test, together with information from the classroom teacher, were used to establish the students learning being approximately 6 months behind the expected class level. The teacher completed a questionnaire prior to the commencement of the program asking about the

learning behaviours of each of the students. The students were given a clinical interview that consisted of a vignette in which a fictional story was used to stimulate discussion on the types of actions learners do to improve their learning. As well, during the interview the students were given the ladder instrument (Mornane, 2010). This involved students being shown three statements from fictional students discussing how they believed they learnt mathematics best. The students were instructed to read these statements and place them on the rungs of a "ladder" in the order they felt they learnt mathematics best. The students were then asked to explain their reasoning. All of these data, along with other data not referred to in this paper, were intended to give a rich picture of both the students' academic level as well as their actions and attitudes towards learning mathematics.

At the conclusion of the program the class teacher was again given a post questionnaire asking about the learning behaviours of the students. The post program student interview incorporated the vignette and the ladder instrument as well as questions about what they felt they had learnt in the program, the value of the program and whether they would recommend such a program to other students. The student interviews were recorded and later transcribed. Parents of the students were given a questionnaire at the conclusion of the program. They were asked to report any noticeable changes in their child's learning behaviours. The students were also given the relevant PAT Mathematics test to measure perceived mathematical growth.

Longitudinal data has also been collected, twelve months and two years after the program. This consisted of the parents being given follow-up questionnaires which sought to explore parent' perceptions on how their child was progressing academically in mathematics as well as the learning actions and attitudes of their child. The students were also interviewed at these times and questioned about their actions and attitudes towards learning mathematics. These later data were collected in an attempt to track the longevity of the changes in the students' mathematics learning and disposition.

Results

Due to limitations in the size of this report, the results discussed only refer to that subset of the data collected about Phase 1 students prior to the program and then two years after completing the program, as the focus of this paper is on positive sustainable changes from the *Prepare 2 Learn* initiative.

As the students had moved onto secondary school the data collected two years on were limited to information from the parents and the students. Both of these sources were intended to give a picture of the impact of the program on these students' learning at the end of year 8. After speaking to all three of the students' parents, it was clear that academically the students were continuing at expected level or, for two of the students, well beyond what would have been expected. The first student, Rachel, at the end of year 8 had received an A (80%+ on written work and/or examinations) on her school report and had been invited to take part in the year 9 mathematics extension program. This student had also won an Academic Excellence Award in mathematics for achieving the highest grade average in her class of 30 students. The second student, Jessica, at the end of year 8 had received a C+ (65-69% on written work and/or examinations) on her report. The third student, Elise, who attended a different secondary school, had also received A (80%+ on written work and/or examinations) in her final report and had been invited to accelerate to year 10 mathematics the following year, rather than year 9. Notwithstanding other factors may have contributed to these results, the students' success suggest that the aims of the *Prepare 2 Learn* initiative were achieved, as all three students had continued to be at or

above the expected mathematics level for their year. Further the qualitative data collected from the students and their parents were suggestive of various positive changes in students' mathematics disposition. These included: increased confidence in class and in mathematics; greater participation in classroom learning experiences; and more responsibility taken by students for their learning. Importantly these changes which had been evident in data collected immediately after the program, had been maintained or improved 12 months and 2 years after the intervention. Due to the size of this paper and a desire to ensure sufficient details of changes, the following results focus on one of the students, Rachel, and the data which relate to her showing more responsibility for her learning through her actions and attitudes.

Initially, the pre-program data suggested Rachel believed she was trying to be a responsible learner but circumstances were preventing her from doing this adequately. For example, in the pre-ladder instrument Rachel was given three statements by hypothetical students on how they learnt mathematics best. Rachel was asked to read the statements and put them in order of her preferences for learning mathematics. The three statements, using hypothetical student names, were as follows:

> Julie said "I learn maths best when I listen carefully and do the problems as the teacher suggests"
>
> Corey said "I learn maths best when the teacher lets me work out my own way to do the problems"
>
> Aimee said "I learn maths best when the teacher puts us in groups to do the problem"

Rachel explained that her least favourite way to do mathematics out of the three choices was, listen to the teacher and do the problem exactly as the teacher says. When questioned about this she explained

> Yes because I normally forget what the teacher tells me to do. I know it and when I get back to my desk I forget the next step, because she says it all once and doesn't repeat it sometimes, so I don't get it.

She then continued "I listen carefully and do what she suggests, but it never works." When questioned about whether she asked for help when she was having difficulty she replied

> I do but sometimes I wait and she goes to another person and forgets me and I try but then it's the end of the lesson and they never come to help.

Phrases such as "she says it all at once", "doesn't repeat the steps" and "they never come to help" present a picture of a student who believed that her learning was being hindered by forces beyond her control. Interestingly, the teacher had commented in the pre-program data that Rachel is "easily distracted" and "needs to stay on task". Perhaps these comments explain why Rachel was having difficulty understanding the learning instructions from the teacher.

Rachel was also posed the vignette prior to beginning the program to try to ascertain actions Rachel believed could assist a student to learn. The vignette was a picture of two girls, Sally and Bridie (also hypothetical). Rachel was told that these girls in year 3 were both getting the same marks in mathematics. Although remaining in the same mathematics classes, in year 6 Bridie was doing a lot better than Sally. Rachel was asked to suggest reasons why this may have happened. Rachel responded "Maybe she got a tutor, and she was more smarter (sic) than Sally". These comments suggested Rachel may have begun the program with a fixed mindset. She saw Bridie's improvement as having to do with the support of a tutor or innate talent, rather than a consequence of her learning actions.

Rachel also mentioned, in one of the intervention sessions, that sometimes when she is sitting on the floor listening to the teacher's instructions, other students speak to her. When

asked “How can you overcome this problem?” Rachel replied that the students were often asking her questions about something the teacher had said, rather than just talking to her in general conversation. When again questioned “So what are you going to do to stop these students causing you not to hear what the teacher says?” Rachel responded that she would need to explain to the student that if he or she is unsure the best thing to do is to ask the teacher, as she really needs to listen to the teacher’s instructions herself. This solution by Rachel was the beginning of her understanding the type of responsible learning actions she needed to initiate.

This pre-program data collected from Rachel suggested that Rachel believed she was doing her best to be a responsible learner but problems like the teacher not coming to assist her when she put her hand up, instructions not being repeated, other students talking to her on the floor, were the types of issues that were preventing her from learning.

In contrast, data collected from Rachel at the end of year 8 indicated she no longer saw issues like these as inhibiting her learning. When asked in an interview two years later about the types of actions she needed to do to help her learn mathematics better, Rachel replied

> I just reckon like once you do one equation I reckon keep, like do like, don’t do the same one again and again ‘cause of course you know the answer but do like the same steps and just like different like setting-out. Like do the same steps, like keep going over it and like just do it like until you feel confident with it.

This suggested that Rachel at the end of year 8 was a student who was aware of the actions she could put into place to ensure she learnt. When asked what she does when she is given a difficult mathematics problem, Rachel responded

> Well first I try and work it out and then I check the answers to see if I got it right. Well it depends what equation it is ‘cause if you can substitute it, then I substitute it and if my answers wrong I try and do it another way. But if it doesn’t work then I probably look at the answers first, and then when I look at the answers and then I figure out how to do it and then I realised I might’ve plused when I should’ve minused and I realise what I’ve done. But then if like the answers don’t help, I”ll get say a family member to help or like a teacher, just someone around me just to help me.

This statement by Rachel shows what a responsible learner she had become. She discussed the need to practice doing equations over and over to ensure the method becomes automatic. When presented with a challenging problem she tries it and if applicable, for example algebra, substitutes the answer back into the equation to check if she is correct. If incorrect, she tries again but using a different method. If still incorrect she gets the answer and then tries to work backwards. Here she speaks about the fact that she may have just added or subtracted incorrectly, suggesting she feels confident she can do the mathematics but may have made a careless error. She then goes on to say, if she still cannot get the answer she asks others for help and mentions a number of possible agents that might be able to help her. These statements suggest that Rachel is a learner who is not looking to just have the correct answer but she is focused on the understanding behind the answer.

When Rachel was asked if she had changed in the ways she goes about her learning since being part of *Prepare 2 Learn* program, she began answering by discussing what she was like before the program

> Well every time I knew like say the answer I wouldn’t put my hand up ‘cause I didn’t want to be wrong…’cause like I’m (I was) nervous. And then if I get it wrong everyone’s probably, people who know, are probably gonna go, oh no. So that’s why I get (got) a bit self-conscious…

Then when asked if in year 8 she still felt self-conscious putting her hand up, she replied:

> No, I'm like, I feel cocky now, 'cause I will put up my hand and I'm always like, I know the answer and stuff.

When further questioned about whether it would worry her if she is incorrect, Rachel responded:

> I just ask how and then other people think, other people yell out and say oh I did it that way too, why isn't it. Then say my friend next to me or the teacher will explain it…like (when) learning you make mistakes and then you've got to move on.

These statements suggest that Rachel had become a resilient learner. She is no longer self-conscious about putting her hand up to answer class questions because she is confident she will be correct. However if incorrect, she acknowledges that others in the class may be making the same mistake, so through help from either other peers or the teacher they can all learn and "move on".

Rachel in another question about good learning behaviours went back to discussing the issue of peers asking her questions when she is trying to focus on the teacher's instructions or on her own work. She said

> Well if someone's like next to you and they're like, they don't understand anything maybe just ask the teacher to come over and help them with it, if they're like interrupting you on your learning. …So just be aware of your surroundings and stuff.

This statement suggests that Rachel is now mindful as a learner when the actions of her peers prevent her from learning and she has developed strategies to cope with this type of situation, for example, calling the teacher over to assist the student. In contrast, the pre-program data discussed above had Rachel feeling frustrated when another student was asking her questions when she was trying to listen to the teacher's instructions.

To gain a different perspective, Rachel's mother was given a questionnaire at the conclusion of the program, 12 months after the program and then again two years after the program. Each questionnaire asked the mother about changes she had noticed in her child's actions and attitudes towards learning mathematics, as well as asking whether the program had been worthwhile for her child. Rachel's mother had always worked closely with Rachel helping her with her mathematics homework and in each of the questionnaires she spoke of significant changes she had witnessed. The questionnaire immediately after the program, when Rachel was at the end of year 6, the mother commented

> She commenced (the program), with no confidence, particularly worded maths questions. She actually was unable to do (them), without assistance.

In the questionnaire two years after the program Rachel's mother was asked to comment on changes she had noticed in her child's actions or attitudes since being part of the program. She then wrote the following in dot points

- Increased enthusiasm to study maths and other subjects that incorporate maths
- Not frightened to tackle a problem
- Problem solves her own solutions by using YouTube or e-books
- Enthusiasm to study for end of semester examinations
- Goal setting and prioritising exam preparation on her own

These points show that the mother had noticed that Rachel had become a responsible mathematics learner since being part of *Prepare 2 Learn*. Actions like attempting to solve challenging mathematics problems, looking up YouTube or e-books to assist with these and other problems and preparing for exams by planning and studying, are all responsible learning behaviours. They suggest that Rachel had developed a growth mindset, as she was aware that through hard work she could become better at mathematics. It is important to

note, significant improvement in responsible learning behaviours was evident in all of the students that participated in the *Prepare 2 Learn* program, not just Rachel.

Conclusion

In conclusion, the data suggest that the *Prepare 2 Learn* intervention program has made positive sustainable changes in students' mathematics learning and disposition. This was evident when looking at the above data and other data not included in this paper. Rachel's positive disposition became even more evident when asked at the end of the interview if she thinks she will continue to do mathematics in year 11 and 12. She replied

> Definitely because, even if, like people they don't want maths in their, they don't want to do maths 'cause they hate it or something in their job, like I feel like that's a bad choice because you should be doing it either way, in just life. Like what happens if you come across a sale or something when you go shopping, you don't know how to do it, it's like well you should've done math. And even if it's in your job like continue it. And I'm gonna continue it 'cause what I want to be is something with probably like maths or science, like something going in that direction 'cause I feel like I'm really good at it, so I can, like if I really like it and enjoy it I want to like go into the (that) path.

This statement of Rachel's summarises what most mathematics teachers hope they can instil in their students. An appreciation of mathematics as well as an understanding that mathematics is useful not only to help you get good grades but as a tool that will continue to help you in your future life. As Middleton and Jansen (2011) state

> The goal for every mathematics classroom teacher…goes way beyond cultivating "mastery" in their students. It is to enable their students to develop mathematics as a personal long-term interest. (p. viii)

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