Scaffolding pedagogy: improving mathematics teaching and learning

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

Summary

To improve student learning outcomes in numeracy there needs to be a focus on developing teachers' pedagogies and knowledge. In this initiative, specific attention was given to enhancing teachers' content knowledge, pedagogical knowledge, and pedagogical content knowledge in numeracy. While the particular goal was to improve the numeracy learning outcomes of Aboriginal students, the initiative was beneficial for all students. (Although this initiative was part of a national program that focused on numeracy learning for Aboriginal and Torres Strait Islander students, there were only Aboriginal students in these schools.)

This strategy was based on the Accelerated Literacy (AL) approach (Gray 2007), which was used as an impetus to develop pedagogy to improve the numeracy outcomes for Aboriginal students. The initiative was part of the Australian Association of Mathematics Teachers' project Make it Count: Numeracy, Mathematics and Indigenous Learners, and it was funded by the Australian Government as part of the Closing the Gap initiative.

Target student group

This strategy was developed in response to the numeracy learning needs of Aboriginal students in the primary schools involved, but the enhanced pedagogy was good for all students. Its objectives were to:

- enhance Aboriginal students' understanding of number concepts in years F–7
- develop Aboriginal students' efficiency and fluency in number
- build Aboriginal students' mathematical language
- develop and document a model for numeracy pedagogy built on the scaffolded pedagogy of AL.

Over the three years of the project, 80 teachers and four principals across a cluster of four state primary schools in metropolitan South Australia were involved, and the impact was largely monitored for 75 Aboriginal students. The lead school was Noarlunga Downs Primary School. The other schools were Huntfield Heights Primary School, Christies Beach Primary School and Hackham West R–7 School.

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

Method

This strategy went through several phases over three years. Throughout the three years, the staff were challenged and supported by external 'critical friends', who were experts in their field.

What proved to be important were not the pedagogies or programs that were employed – although these did prove to be successful – but rather the processes employed to develop a collegial sense of site-based and data-driven professional development.

Initial phase

The initial inquiry was to build numeracy language and mathematical thinking for students by building on the successful scaffolded pedagogy of AL to accelerate numeracy. Early lessons were videotaped and then reviewed by the teachers in the cluster and two critical friends: one with expertise in AL and the other with expertise in mathematics. Through this, it was clear that the lessons were well sequenced and language-rich, but poor in terms of the mathematical content. While this was quite an uncomfortable realisation for all involved, it led to a significant realisation that strong pedagogic practices need to be supported by deep content knowledge.

Teacher learning phase

The teachers made a collective decision to develop their content knowledge of number by engaging in the Big Ideas in Number program with Professor Di Siemon. The basis of the program is that:

> For students to become numerate, concepts need to be experienced, strategies need to be scaffolded and EVERYTHING needs to be discussed for them to learn with understanding. (Siemon, 2007).

As a part of this phase, teachers undertook careful observations of the students, and it was clear that many students did not understand key conceptual ideas that it had been assumed they had learned previously.

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

Teacher planning phase

Through the targeted professional development and student observations, the teachers were able to plan lessons that focused on enabling students to become confident and efficient in key mathematical skills and concepts. Lessons were developed by first articulating a clear learning goal, and then backward mapping to develop a learning sequence that would enable students to meet that goal.

A critical aspect of the lesson sequence was the 'joint conceptualising/meaning-making' component, where students share their mathematical strategies and realise that there can be more than one way to solve a problem. Through thoughtful questioning, students are encouraged to verbalise their thinking and this gives the teacher insights into the students' understanding; this was called 'handover'. Handover is more than simply supplying correct answers, and was shown when students could explain their understanding and make links to other concepts or learning. Evidence of understanding was garnered through deep-structured questions that were pre-formulated, and then reconceptualised as required as the lesson progressed.

In essence, the pedagogical approach involved scaffolding student learning of mathematics through a structured, coherent approach, built on the principles of AL. Each lesson began with a clearly articulated learning goal, and then progressed through the stages of low-order orientation, high-order modelling, application, and joint conceptualisation/meaning-making, resulting in handover to students. In this way, deep learning was promoted. The approach had an explicit focus on the language of mathematics so that students had the vocabulary and concepts to communicate their mathematical understandings.

Teacher reflection and evaluation phase

As the teachers used the new forms of pedagogy in their mathematics classes, processes were established to allow for teacher reflection and evaluation. Classroom observations were a key feature throughout the project and – apart from the classroom data it elicited – the process of observing a lesson in a colleague's classroom generated a strong sense of collegiality and shared vision. A lesson-observation tool was developed that allowed data to be collected on student engagement in the lesson; the extent to which the questioning elicited deep understanding; and the degree of handover evident. This allowed teachers to reflect on their own teaching and evaluate the extent to which students met the behaviour and learning goals of the lesson. The teachers found the learning for both the observer and observed to be invaluable, and it led to improvements in the teaching practice of all involved.

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

Sharing phase

The teachers became accustomed to having colleagues in their classrooms. Key teachers also opened their classrooms to critical friends, school leaders, families and visitors from other schools and organisations. Furthermore, various staff members have presented their processes and findings at conferences and published their stories on the Make it Count website.

An important feature has been the attempts to engage with families, to help them appreciate the approach to numeracy learning, and to assist parents and carers as they support their children. During a Maths Mania Day, a visitor commented:

> The students that I visited were excited to have visitors in their classroom and proud to be able to show them their understanding of a mathematical concept or procedure. Each child that I interacted with was able to explain clearly and confidently, and had carefully prepared their teaching. They scaffolded the learning for me. For example, when teaching me to use BODMAS, they initially went through the terminology. They then demonstrated for me (using an example) how to use the sequence. They then asked me to try an 'easy' one with their assistance before challenging me to try one on my own. It was clear to me that the students had been taught in this manner and that it had been a successful way for them to learn. (Visiting teacher)

Results

Evidence was collected through a range of methods to monitor student learning, including progressive achievement tests (PAT-M) and NAPLAN results. Also, interviews with staff, students and families were undertaken, and case studies and stories developed to provide insights into the broader impact of the strategy.

Student learning outcomes

The data indicated that the pedagogical reforms lead to improved student learning outcomes in numeracy. As would be expected, the greatest growth was seen in the Reception to year 2 students. (Reception is the first year of school in South Australia.) These students had experienced the new pedagogy consistently through their numeracy education, whereas the older students needed to revisit foundational ideas that were underdeveloped before moving on to more age-appropriate learning. However, growth was still noted in older students' number knowledge.

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

Across the schools, the mean growth in scale score for students taking PAT-M tests 1 to 4 during the six-month period from March to September 2012 was 11.0, 9.0, 5.9 and 3.9 respectively, and this compares with expected growth in scale score of approximately 8, 7, 3 and 3 (based on ACER norm-referencing charts).

Similar, although not universal, gains were seen in the results of the Aboriginal students. Furthermore, comparisons of the NAPLAN results for the 20 Aboriginal students who participated in the assessments between 2009 and 2012 showed an average growth of 49.4 points, with seven of these students achieving growth of 90 points or more.

Overall, the external quantitative data suggested that students from Aboriginal backgrounds maintained a level of growth that was at least equal to, or slightly better than, that which might be expected, and that all students benefitted from the program.

> Rob was a year 1 student who initially presented in class as a shy, withdrawn, disinterested Aboriginal student, with many absences and virtually no oral participation in the class. This was his first exposure to the Make it Count pedagogy, in which an explicit learning goal was identified for each lesson, clear explanation of terminology related to the topic given and a scaffolded approach used to develop the concept. Almost immediately, Rob began to answer questions and give explanations on how or why he had arrived at his particular solution. Not long after this change, I saw his mum and expressed to her my pleasure at Rob's participation and enthusiasm for maths. I could note her obvious pleasure in receiving the news. Now he is rarely absent and Rob's participation rate and confidence continues to grow. He has also gained respect from his peers and they seek to work with him, knowing that he is able to help them if they are struggling. For me, the teaching style has helped change my teaching strategies to ensure that not just a basic concept is introduced but also to ensure the concept is understood and used. I found explicitly teaching the maths language – both understanding the variety of terms used and having the ability to read the maths terminology – beneficial for all of my students. The scaffolding helps to consolidate concepts by building and expanding on previous steps. I could easily see if students had mastered a concept or if I needed to revisit it again. I now find myself using these strategies with success in other areas of the curriculum. (Jenny Ferguson)

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

Staff and school outcomes

Through the project there were many developments across the schools. These contributed to the success of the initiative, and have also become integral features of the schools' culture and operations.

- Teachers are more intentional and focused in their pedagogy.
- Teachers' perceptions and understanding of mathematics have developed; for some, this has meant that their fear of mathematics has decreased, and they have developed a belief that all students can learn mathematics.
- Teachers have become more aware of the specific needs of Aboriginal students, and this has included encouraging the involvement of the local community, particularly parents.
- Teachers have become more open to sharing practice. The lesson-observation proforma allowed teachers to give and receive non-judgmental feedback; the act of observing and giving feedback was as powerful as receiving it.
- A specific focus on the language of mathematics led to students becoming more able to express their ideas.
- Teachers developed leadership skills through reflecting and evaluating their practice and sharing with other teachers. Through this, they were able to develop a better understanding of how change occurs and become active in driving a wider school improvement agenda.
- The profile of mathematics in the schools has increased and teachers have shared their passion for mathematics with the wider community, and shared their results at conferences and in news bulletins.

Lessons learned

The importance of teachers' content-specific knowledge

The initial design of the strategy was to develop numeracy pedagogy from an understanding of AL. However, it became clear early on that the teachers needed to develop deep content knowledge and pedagogical content knowledge in mathematics, and that teaching mathematics contained different challenges to teaching literacy. Hence, it was vital to increase teachers' specific mathematical content knowledge.

The power of collegial classroom observations

Another powerful lesson was the value of peer observations of classrooms. This was very uncomfortable for teachers initially but, through perseverance, it proved to be instrumental in changing practice. As has already been noted, these observations were valuable learning experiences for the teacher being observed – who obtained specific feedback – but equally so for the observer.

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

The importance of mathematical language

The pedagogical approach developed explicitly focuses on the language of mathematics, giving students the tools to communicate their understanding of mathematical concepts. Students were scaffolded in their mathematical language through discussion of the specific register of mathematics and how it differs from everyday language. This gave students the power to express their mathematical ideas more succinctly and accurately.

Next steps

The initiative was based on the AL model, which had already been successful in the schools, but then adapted to introduce focused, site-based, collegial professional development in mathematics. Through the project, a coherent lesson structure for mathematics was developed that scaffolded student learning.

One principal said:

> We will certainly keep going. We will continue focusing on other strands of maths, beyond Number, using the same scaffolded pedagogy. Next year we will also look at whether this leads us in to applying maths in other curriculum areas: maths in science, history, SOSE, technology.

Now the initiative is complete, each school will take on the learning and development of the last three years and apply it to their particular school in response to the emerging needs. Some schools will also engage in similar focused professional development in other subject areas.

How could other schools engage in a similar initiative?

There are many schools across Australia where AL has been successfully implemented, so large numbers of teachers have been trained in AL techniques and understand the principles underpinning the scaffolding approach. This provides a good foundation for a development project such as this one, but it also requires the in-depth development in mathematical content knowledge and mathematical pedagogical content knowledge.

The approach is relatively cost-effective, as the main expenses are related to teacher development. The expenses are an integral part of the school budget anyway. Also, there is a sense of coherence and efficiency because it uses some of the learning and knowledge already promoted through the literacy program to boost growth in mathematics education.

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

If this initiative were to be successfully implemented in another site, the following factors need to be considered:

- School leadership and staff would need to be committed to a school-wide approach to development, and ideally there would be an identified ‘champion’ of numeracy in the school.
- Teachers in the school would ideally have a background in AL, so the basic principles could be used to develop a deep understanding of concepts such as low- and high-order modelling, joint conceptualisation and handover.
- Teachers need to be committed to developing their content knowledge and pedagogical content knowledge of mathematics. This could be achieved through a structured program such as Big Ideas in Number.
- Schools should ideally engage a critical friend or advisor.
- It is important to have structured and coherent data collection processes to monitor and inform development.

Research base

This initiative was established through engagement with three broad fields of research: AL, Big Ideas in Number, and site-based professional development.

Accelerated Literacy

The foundation of the AL strategy was scaffolding pedagogy, as promoted in the AL program (Gray, 2007). Specifically, this pedagogical approach provides ‘handover’ to students through a highly scaffolded teaching structure.

The key aspects of the scaffolding pedagogy program are:

- consistent and supportive lesson routines and structures
- activities planned so learning is within ‘the zone of proximal development’ (Vygotsky, 1978)
- lessons planned by first deciding on a learning goal, and then backward mapping the lesson plan to facilitate student growth towards that goal.
- regular and sustained focused time: one hour of uninterrupted mathematics per day for four days each week
- focusing specifically on the language of mathematics so that students have the vocabulary and concepts to discuss their ideas.

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

Big Ideas in Number

Big Ideas in Number is built on the premise that teachers need to know the foundational concepts, skills and strategies of mathematics (ie content knowledge), and they also need a deep understanding of how these ideas are best taught and learnt (pedagogical content knowledge) (Siemon 2007). This comprehensive program provides a structured developmental framework for number, including concepts like 'trust the count'.

The Big Ideas in Number program provided the mathematical content knowledge and the mathematical pedagogical content knowledge for the lessons planned using AL structures.

Site-based professional development

Site-based professional development that involves a whole-school focus has been shown to be effective in bringing about pedagogical change and improved student learning outcomes (Bobis et al 2005). A site-based approach means the developing pedagogy can respond to the particular needs of the learners, teachers and community members in that school. Also, a local program of professional development can work within, and work to change, school-based conditions and arrangements that may enhance or diminish effective learning (Kemmis et al 2014).

A number of studies have found that school-wide professional development programs are effective in bringing about effective change in mathematics teaching (Bobis et al 2005; Clarke 1994). When numeracy is the focus of staff development across the whole school, discussions about mathematics learning occur not only in formal meetings, but can also occur as an integral part of the informal sharing in staffrooms. Furthermore, it has been shown that when a staff development program is school-wide and has a particular focus – such as numeracy – this can lead to improvements in teaching and learning in other subject areas.

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

teach learn share

Further reading and links

Bobis J, Clarke B, Clarke D, Thomas G, Wright R, Young-Loveridge J & Gould P 2005, 'Supporting teachers in the development of young children's mathematical thinking: three large scale cases', *Mathematics education research journal*, 16 (3), pp 27–57

Clarke DM 1994, 'Ten key principles from research for the professional development of mathematics teachers', in DB Aichele & AF Croxford (eds), *Professional development for teachers of mathematics*, 1994 Yearbook of the National Council of Teachers of Mathematics, pp 37–48, NCTM, Reston, Virginia

Cowey, W 2005, 'A brief description of the national accelerated literacy program*', TESOL in context,* 15 (2), pp 3–14

Gray, B 2007, *Accelerating the literacy development of Indigenous students*, the National Accelerated Literacy Program (NALP), CDU Press, Darwin

Gray B, Cowey W, & Axford B 2003, *Scaffolding literacy with Indigenous children in school,* final report to the Indigenous Education Branch, DETYA, University of Canberra

Kemmis S, Wilkinson J, Edwards-Groves C, Hardy I, Grootenboer P and Bristol L 2014, *Changing practices, changing education*, Springer, Singapore

Siemon D 2007, *Developing the 'big' ideas in number*, RMIT University, Melbourne, https://www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/devbigideas.pdf

Siemon D 2003, 'Partitioning: the missing link in building fraction knowledge and confidence', *Australian mathematics teacher*, 59 (3), pp 22–24

Siemon D, Breed M & Virgona J 2005, 'From additive to multiplicative thinking: the big challenge of the middle years', in J Mousley, L Bragg & C Campbell (eds), *Mathematics – celebrating achievement*, Proceedings of the 42nd annual conference of the Mathematical Association of Victoria, www.eduweb.vic.gov.au/edulibrary/public/teachlearn/student/ppaddmulti.pdf

Vygotsky L 1978, *Mind in society*, (trans M Cole), Harvard University Press, Cambridge, Maine

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.

Contacts

Contact: Marie Wright
Organisation: Noarlunga Downs P–7 School
Email: marie.wright577@schools.sa.edu.au
Phone: (08) 8384 4395
Position: Senior Leader

Lead school: Noarlunga Downs P–7 School
Email: info@ndownsps.sa.edu.au
Phone: (08) 8384 4395
Address: Canterbury Crescent, Noarlunga Downs, SA 5168
Principal: Gaynor Steele
Principal's email: gaynor.steele117@schools.sa.edu.au

Make it Count:
Contact: Caty Morris
Organisation: Australian Association of Mathematics Teachers
Email: cmorris@aamt.edu.au
Phone: (08) 8363 0288
Address: PO Box 1729 Adelaide 5000
Website: http://makeitcount.aamt.edu.au/About

© 2014 Commonwealth of Australia, unless otherwise indicated.

Teach Learn Share is provided under a Creative Commons Attribution-Share Alike licence (CC BY-SA 3.0 AU), unless otherwise indicated.