The Impact of Two Teachers' Use of Specific Scaffolding Practices on Low-attaining Upper Primary Students

Sarah Ferguson
Australian Catholic University
<sarahferguson@exemail.com.au>

Andrea McDonough
Australian Catholic University
<andrea.mcdonough@acu.edu.au>

This paper reports on two upper primary teachers' use of particular scaffolding practices, individual discussion and the use of manipulatives. The cognitive and affective impact on four low-attaining students in these classes is described. The teachers and students were observed during eight to ten sequential tasks. "Scaffolding conversations" emerged as a common practice for these teachers whilst the use of manipulatives represented a point of difference.

One of the greatest challenges faced by education systems, schools and teachers is supporting students who are low attaining in mathematics. Part of this challenge is that teachers are called on to teach conceptually challenging mathematics to all students, both as a matter of equity and in recognition that conceptual understanding is essential for students to become "proficient and sustained learners and users of mathematics" (Numeracy Review Panel, 2008, p. 62). However, in order to teach using cognitively challenging tasks, teachers need a form of assistance that allows such challenge to remain whilst providing support for low-attaining students. Anghileri (2006) suggested that scaffolding was appropriate for this kind of "constructivist paradigm for learning" (p. 33).

Scaffolding (Wood, Bruner, & Ross, 1976) first emerged as a metaphor to describe a particular type of assistance used to support student learning. Rosenshine and Meister (1992) defined scaffolding as

> … forms of support provided by the teacher or another student to help students bridge the gap between their current abilities and the intended goal … Instead of providing explicit steps, one supports, or scaffolds, the student as they learn the skill. The support that scaffolds provide is both temporary and adjustable. (p. 26)

Scaffolding can take various forms from a "transmissive" style from teacher to student in a "predetermined sequence" to a more fluid exchange in which both student and teacher participate in a "mutual appropriation … of each other's actions and goals" (Goos, 2004, p. 263). This paper reflects this latter definition.

The case study from which data have been selected for this paper centred around the question, "How does a teachers' use of particular scaffolding practices, while using specific mathematics tasks, impact on low-attaining students cognitively and affectively?" For this paper, two aspects of scaffolding will be discussed: one-to-one discussions between the teacher and students and the teachers' use of manipulatives.

Anghileri (2006) offered a three-tiered hierarchy of scaffolding levels that culminated in conceptual discourse. Anghileri described this third level of scaffolding as "teaching interactions that explicitly address developing conceptual thinking by creating opportunities to reveal understandings to pupils and teachers together" (p. 47). Conceptual discourse focuses on making connections between different ideas in mathematics and on "the communal act of making mathematical meanings" (p. 49). Cheeseman (2009) described such interactions between a highly effective teacher and one young child. These conversations were quite intense, allowing the teacher to gain important insights into that student's understanding and allowing the student to ask questions or make conjectures.

L. Sparrow, B. Kissane, & C. Hurst (Eds.), *Shaping the future of mathematics education: Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia.* Fremantle: MERGA.

These moments offered rich opportunities for the teacher to scaffold that particular student's understanding through careful questioning, specific explanations, or by making links to situations, representations, or manipulatives that resonated with that student. McCosker and Diezmann (2009) warned that not all conversations between the teacher and a student could be considered scaffolding. This study gave examples of the teacher offering encouragement but asserted that scaffolding differed in that it involved the teacher demonstrating "an awareness of and responsiveness to the students' thinking" (p. 33) and encouragement for "creative and divergent thinking" (p. 27).

The use of manipulatives is often advised as a way of scaffolding learning in mathematics. Within the literature there are many definitions of the term 'manipulatives'. For this study, we drew upon Goldin and Sheteingold's (2001) description of external systems of representation. We also recognise the differences in how manipulatives can be interpreted, as discussed by Boulton-Lewis (1992), in that "some of these are concrete embodiments of mathematical concepts and processes and others are representations inherent in the discipline of mathematics" (p. 1).

Studies have shown that using manipulative materials was successful for developing students' understanding of concepts such as area (Cass, Cates, & Smith, 2003) and fractions (Butler, Miller, Crehan, Babbitt, & Pierce, 2003). Other studies warned that the use of concrete materials could confuse children further if they did not have the mathematical understanding to connect the materials to the relevant concept of skills (Ball, 1992). Ambrose (2002) found that some students, in particular girls, can become "stuck" on using materials instead of developing more sophisticated strategies. Boulton-Lewis and Halford (1992) suggested that some use of representations increased the cognitive load of students, thus inhibiting progress. Sowell (1989) suggested that a key to the successful use of concrete materials was long-term use of the materials and the teachers' knowledge about using the materials. Stacey, Helme, Archer, and Condon (2001) also suggested that the transparency of the materials to illustrate clearly the intended mathematical concept was critical to their successful use.

The literature discussed above suggests that scaffolding conversations have the potential to support students in their mathematics learning but that there are differing findings on value of the use of manipulative materials. The impact each of these strategies might have on low attaining learners of mathematics has not been widely explored in the literature but formed the focus of the wider case study and this paper.

Method

This paper draws on data collected during a case study investigating scaffolding practices of two upper primary teachers and the impact on two low-attaining students in each of these classes. As stated earlier, two aspects of scaffolding are discussed in this paper: one-to-one discussions between the teacher and students and the teachers' use of manipulatives

Participants

The first teacher, Ms B, had five years of teaching experience, with two years experience in teaching Year 5. Two students in Ms B's Year 5 class, Carl and David, were targeted for data collection. Both were operating about 12 to 18 months below expected levels in mathematics according to the *Victorian Essential Learning Standards* (Victorian Curriculum and Assessment Authority, 2006).

The second teacher in this study, Ms L, had eleven years teaching experience. The two target students from Ms L's class were Sophie, a Year 5 girl, and Riley, a Year 5 boy, both operating at about 12 months below expected levels in mathematics according to the *Victorian Essential Learning Standards* (Victorian Curriculum and Assessment Authority, 2006).

Data Collection and Analysis

Though a number of data collection procedures were employed in the research, only some of these are drawn on for this paper. For the teachers, these include a researcher-developed Tasks Questionnaire; a drawing task titled, "a time I taught mathematics well", adapted from the Pupil Perceptions of Effective Learning Environments in Mathematics (PPELEM) procedure (McDonough, 2002); and interviews with the teachers before and after observed lessons. Each lesson was audio-recorded with the teachers wearing a mobile recording device. Data on the target students were gathered via lesson observations and an interview after each lesson. There were two parts to these interviews. Firstly the interview focussed on the students' feelings about the tasks and their teachers' actions. Secondly a short assessment piece was given that aimed to assess understanding of the concept of major focus within the lesson. During the lesson, interactions between the students and their teacher were audio taped. In this way data regarding possible cognitive development and affective factors were collected. Lesson observations occurred over eight to ten sequential mathematics tasks in each class. In Ms B's classroom, all the observed tasks focussed on concepts of decimals, fractions and percent whereas in Ms L's classroom, the tasks focussed on multi-digit multiplication.

Interviews and lessons were transcribed and detailed lesson observation notes written for each observed lesson. These data were analysed using the *NVivo* program (QSR International, 2005). Data from a variety of sources, including the questionnaire and drawing tasks, built up a "rich, thick description" (Merriam, 1998, p. 38) of the teachers' and target students' experiences of their mathematics classrooms. We then "searched for patterns" (Stake, 1995, p. 44), seeking common themes but also recognising instances that differed from such themes in an effort to "come to know the case well" (Stake, 1995, p. 8).

Results and Discussion

This paper will focus on a point of similarity between the two teachers, that is, scaffolding conversations, and a point of difference, which was the teachers' use of manipulatives. The impact of these practices on the target low-attaining students in each class will also be described.

Scaffolding Conversations

Both Ms B and Ms L used conversations with the target students to attempt to scaffold their understandings. The use of these scaffolding conversations emerged as important moments for the students both cognitively and affectively. Drawing on the work of the studies described above, we have defined particular conversations between the teachers and the target students as *scaffolding conversations*. Scaffolding conversations are those interactions that took place between the teacher and individual students where the focus was mathematics as opposed to organisational or behavioural issues, where the teacher showed an awareness and responsiveness to the students' thinking (McCosker &

Diezmann, 2009) and where the teacher appeared to facilitate the development of understanding of mathematical concepts (Anghileri, 2006).

Ms B and Ms L habitually walked around their classrooms during mathematics tasks talking to students individually or in pairs while they worked on the tasks. These interactions often began by the teacher asking a question such as, “How did you get that answer?” or “What are you going to do next?” A scaffolding conversation with particular students usually occurred in ‘chunks’ over the course of a lesson with the teacher coming and going then resuming the next part of the conversation, a process also described by Cheeseman (2009) as *interlinked conversation strings.*

An example of a scaffolding conversation from Ms B’s classroom occurred with David during a lesson on fractions that used Cuisenaire rods. The first part of the conversation centred on Ms B scaffolding the concept that the number of parts in one whole names the fraction, in that case, two parts is halves. Ms B returned later to continue this conversation:

Ms B: So how do you know it’s a quarter?

David began to use the red rods and placed them beside the brown rod.

Ms B: What are you checking to see?

David: What it is. I’m kind of measuring it. (*He was moving small red rods along the longer rod*).

Ms B: Yeah and what are you checking to see with those red ones?

David: See if it’s a quarter or not.

Ms B: How would you know if it is a quarter?

David: An ordinary guess.

Ms B: No, you’re absolutely one hundred percent right. I’ll tell you that. But how did you know that?

David: Because I went like this … (*He was moving small red rods along the longer rod*).

Ms B: How many parts were you checking to see …? How many parts fit?

David: Four.

Ms B: So how do you know that’s quarters?

David: ‘Cause there’s four pieces.

In this scaffolding conversation, Ms B linked the manipulatives to the concept of the number of parts naming the fraction. David seemed to be ‘on the way’ to understanding this. Through these interlinked exchanges his understanding appeared to be strengthened as later in this lesson David spontaneously offered that three parts would be thirds. David’s affective response was expressed in the following comment after the lesson:

> I was happy because that was pretty easy until I got up to number 6, ‘cause I knew it all. Ms B helped me a little bit. She told me the parts. If I was doing good, she’d say “you’re on the right path”, “you are doing good”.

In Ms L’s classroom, the students were working on multi-digit multiplication. Ms L engaged in a scaffolding conversation with Sophie about multiplying 9 times 87:

Ms L: So now, how can you tell me what 9 times 87 is? What can we keep doing here?

Sophie: Keep adding on 87.

Ms L: Until you’ve added it?

Sophie: Until we’ve got 9.

> Ms L: Okay, that will give you the right answer so that's one strategy because addition … multiplication is when we keep adding the same number over and over and over again. So keep adding on for that please.

Although this seemed an inefficient strategy, Sophie demonstrated an awareness that multiplication can be thought of as repeated addition. The teacher made the decision to leave Sophie to follow her strategy but returned after about eight minutes:

> Ms L: How are we going here Sophie? Okay if you think … this is pretty time consuming isn't it? So let's look at … if it's 9 times 87, do you think perhaps we could use our knowledge … how do we multiply by 10? So 10 times 87 which would be what?
>
> Sophie: 870.
>
> Ms L: Okay, spot on. But we only want to multiply 9 times so what do we have to take away from 870 to make it correct?
>
> Sophie: Ahhh… 87?
>
> Ms L: Because we've multiplied one extra. So you do 870 take away 87. See if that will help you. That will be a quicker … if that's going to help you because that's a quicker way of doing it, isn't it?

In this exchange, the teacher offered a more efficient strategy after Sophie had experienced for herself how time consuming her repeated addition strategy was. In her post-lesson interview, Sophie said

> I got confused trying to find the answer to 9 times 87. Then I used subtraction. If you do 10 times 87 it will make 870. If you minus 87, it gets to 783. If I kept adding 87 to my answer it would've taken a long time. It was Ms L's idea.

The conversation Ms L had with Sophie appeared to make an impact on her strategy choice. Sophie realized her strategy was inefficient and could see the value in a more efficient strategy suggested by her teacher, so much so that she independently used the strategy in later lessons indicated by the following observation:

> She was trying to work out 9 x 7. After a minute she said, "I could just do 10 times 7 and take off 7 to get the answer".

Both these examples show that the scaffolding conversations the teachers had with low-attaining students resulted in progress, either by strengthening understanding or illustrating the use of a more efficient strategy. The teacher can be observed holding back initially from telling the students the answer or strategy. In each case, the teacher scaffolded the students' understanding through careful questioning and responded to the students' thinking (McCosker & Diezmann, 2009), emphasising conceptual connections (Anghileri, 2006) that facilitated progress.

The Use of Manipulatives

Both teachers indicated that they felt 'tasks using manipulatives' were most appropriate for low-attaining students (Tasks questionnaire). However, Ms B and Ms L differed in their use of manipulatives. Ms B was observed using manipulatives with her students, including dice, cards, number lines, Cuisenaire rods and puzzle pieces, for all tasks while Ms L used playing cards for one of the observed tasks.

Perhaps an indication of the difference in Ms B and Ms L's approach to manipulatives is that while Ms L drew and labelled 'manipulatives available at all times' in her drawing of teaching mathematics well (drawing task), on the same task Ms B drew and labelled 'students using manipulatives – cards, dice, games, counters'. In interviews with the teachers, Ms L talked about being dissatisfied with both the organisation of manipulatives so that students had easy access to them and students' resistance to using materials. During one observed lesson Ms L said to the students:

> You might want to use concrete materials. If you need to use them or would like to use them, please feel free. We've got the MAB [Multi-based Arithmetic Blocks] at the back. If you think that's going to help you, get it out. You know that. You don't need to wait to be told. Okay?

No students were observed using MAB in this lesson.

A further difference in each teacher's use of manipulative may reflect Boulton-Lewis' (1992) description of manipulatives as 'concrete embodiments' of concepts or as more formal notations, 'inherent to the discipline of mathematics'. Ms L's use of playing cards, the only instance of manipulative use observed in this classroom, was as a tool for generating random numbers, symbols of mathematics.

The impact Ms L's use of playing cards had on Sophie and Riley was mixed. Sophie was observed having difficulty understanding the game and then struggled to correctly answer the multiplication equations to find products. Riley also spent most of the time for this game trying to calculate nine multiplied by eight. Ms L suggested he use an array but Riley didn't know what an array was. Ms L showed him and he drew an array of nine by eight although his final answer was incorrect.

After this lesson Sophie said:

> I'm still figuring out what to do, still a little bit confused about finding the answers.

Following the same lesson Riley stated:

> [The lesson was] good because it was something different and we get to use playing cards and do the maths questions.

Riley seemed to enjoy the use of the cards in this lesson, although his understanding of products and factors did not seem supported by their use. Sophie recognised her struggle with the task and did not express the same positive response toward using the cards as did Riley.

In contrast, in Ms B's class, manipulatives were distributed to every student and formed an integral part of the tasks, often more aligned with the 'concrete embodiment' idea of manipulatives (Boulton-Lewis & Halford, 1992). Ms B's use of manipulatives seemed to have a positive effect both cognitively and affectively for the target students, Carl and David. As discussed above, David's understanding that the number of equal parts names the fraction was strengthened through his use of the Cuisenaire rods. In a post-lesson interview Carl revealed his affective response to these tasks:

> It was pretty fun cause it was about fractions. I got to build stuff.

The difference in Ms B's and Ms L's use of manipulatives seemed to centre around whether their use was a planned part of the task or an optional extra. Ms L had manipulatives available but their use was dependent upon the students making the choice to use them. Neither the tasks themselves nor the teacher required such use. In contrast, Ms B gave the manipulatives to the students and completing the tasks required their use. These differences may be due partly to the mathematical content covered by each teacher. It is possible that fractions, decimals and percent concepts lend themselves more to the use of manipulatives in a way that multi digit multiplication does not. Where manipulatives were used, they appeared to have a positive impact on the students. We can see from the example of David and the rods (above) that manipulatives supported his growing understanding. Furthermore, Carl found such use engaging and motivating. Riley also indicated a positive response toward the use of playing cards although his understanding did not seem supported by this use. Sophie indicated no response to using the cards and recognised her own confusion during this task. If there were systematic use of manipulatives within Riley and Sophie's mathematics lessons, it would be interesting to have observed the impact of such use on their learning of multi-digit multiplication.

Conclusion

This paper has described two teachers' use of scaffolding conversations and manipulatives and the impact on low-attaining upper primary students. Scaffolding conversations appeared to have a positive impact on the learning and feelings of the low-attaining target students. These conversations illustrated aspects of Anghileri's "conceptual discourse" in that the teachers created "opportunities to reveal understandings" (2006, p. 47). For example, in the conversations reported in this paper, understandings were revealed about the relationship between the number of parts in one whole and the fractional name for such parts or that multiplying by ten and subtracting one set is the same as multiplying by nine.

The teachers utilised manipulatives in different ways. Ms B's students, who used manipulatives frequently, reported positive feelings about using materials. In addition their understanding appeared to be supported by such use. Ms L's students were observed using manipulatives in one lesson with mixed results. This would appear to support Sowell's (1989) assertion that successful use of manipulatives is contingent on the teachers' long term use and familiarity with using materials.

Scaffolding is a complex process often requiring the teacher to make 'in the moment' decisions to respond to individual student understandings. It is hoped that examples such as those offered here will add to the literature on scaffolding and more importantly, demonstrate how it might be enacted in mathematics classrooms.

References

Ambrose, R. (2002). Are we overemphasizing manipulatives in the primary grades to the detriment of girls? *Teaching Children Mathematics, 9*(1), 16-22.

Anghileri, J. (2006). Scaffolding practices that enhance mathematics learning. *Journal of Mathematics Teacher Education, 9*, 33-52.

Ball, D. (1992). Magical hopes: Manipulatives and the reform of mathematics education. *American Educator, 16*(2), 46-47.

Boulton-Lewis, G., & Halford, G. (1992). The processing loads of young children's and teachers' representations of place value and implications for teaching. *Mathematics Education Research Journal, 4*(1), 1-23.

Butler, F., Miller, S. P., Crehan, K., Babbitt, B., & Pierce, T. (2003). Fraction instruction for students with mathematics disabilities: Comparing two teaching sequences. *Learning Disabilities Research and Practice, 18*(2), 99-111.

Cass, M., Cates, D., & Smith, M. (2003). Effects of manipulative instruction on solving area and perimeter problems by students with learning disabilities. *Learning Disabilities Research and Practice, 18*(2), 112-120.

Cheeseman, J. (2009). Challenging mathematical conversations. In R. Hunter, B. Bicknell & T. Burgess (Eds.), *Crossing divides, Proceedings of the 32nd annual conference of the Mathematics Education Research Group of Australasia* (pp. 113-120). Palmerston North, NZ: MERGA.

Goldin, G. A., & Shteingold, N. (2001). Systems of representations and the development of mathematical concepts. In A. Cuoco & F. Curcio (Eds.), *The roles of representation in school mathematics* (pp. 1-23). Reston, Virginia: National Council of Teachers of Mathematics.

Goos, M. (2004). Learning mathematics in a classroom community of inquiry. *Journal for Research in Mathematics Education, 35*(4), 258-291.

McCosker, N., & Diezmann, C. (2009). Scaffolding students' thinking in mathematical investigations. *Australian Primary Mathematics Classroom, 14*(3), 27-33.

McDonough, A. (2002). *Naive and yet knowing: Young learners portray beliefs about mathematics and learning*. Unpublished doctoral dissertation, Australian Catholic University, Melbourne.

Merriam, S. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Numeracy Review Panel. (2008). *National numeracy review*. Retrieved 2 March 2010 from http://www.coag.gov.au/reports/docs/national_numeracy_review.pdf

QSR International. (2005). *NVivo*. Doncaster, Melbourne.

Rosenshine, B., & Meister, C. (1992). The use of scaffolds for teaching higher-level cognitive strategies. *Educational Leadership, 49*(7), 26-32.

Sowell, E. J. (1989). Effects of manipulative materials in mathematics instruction. *Journal for Research in Mathematics Education, 20*(5), 498-505.

Stacey, K., Helme, S., Archer, S., & Condon, C. (2001). The effect of epistemic fidelity and accessibility on teaching with physical materials: A comparison of two models for teaching decimal numeration. *Educational Studies in Mathematics, 47*(2), 199-221.

Stake, R. (1995). *The art of case study research*. Thousand Oaks: Sage, CA.

Victorian Curriculum and Assessment Authority. (2006). Victorian Essential Learning Standards. Retrieved 2 February 2010, from vels.vcaa.vic.edu.au/index.html

Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*, 89-100.