Scaffolding the mathematics learning of low-attaining students through whole class discussions

Sarah Ferguson
Australian Catholic University, Clairvaux Catholic School
<sferguson@ccsbelmont.catholic.edu.au>

The case study reported here examined three scaffolding practices employed by two teachers in two Year 5 and 6 mathematics classrooms. One scaffolding practice was the use of discussion. This paper describes the use of whole class discussions as scaffolding, drawing upon observations of six mathematics lessons in each classroom and the responses of four low-attaining target students. Implications for teachers on the use of whole class discussions as scaffolding for low-attaining students in mathematics are also explored.

Mathematics teaching advice for a number of years has exhorted the importance of whole class discussion. Educational research has increasingly emphasised "the learning of mathematics as a collective enterprise in sociocultural contexts, rather than as a process occurring only within an individual mind" (Inagaki, Hatano & Morita, 1998, p. 503) . Rather than traditional class discussions in which the teacher initiates a question, students respond and the teacher evaluates this response (IRE, Cazden, 1988), teachers are encouraged to orchestrate student-led mathematical discussion to advance the class' mathematical knowledge. Chapin, O'Connor and Anderson (2003) suggested such discussion supported student learning as "putting thoughts into words pushes students to clarify their thinking" (p 22). Hiebert and Wearne (1993) claimed that "the cognitive and social act of expressing one's thoughts (explaining, describing, questioning, etc.) may be a key in understanding how classroom discourse relates to learning" (p. 420).

Researchers have raised concerns that the level of dialogue required in some mathematics whole class discussions is confusing and difficult for low-attaining students. Baxter, Woodward and Olson (2001) studied low achieving students across five third grade classes. During 34 observations, they "noted only three occasions when low achievers volunteered to speak during class discussions. Moreover when they did volunteer, they offered one-word answers or remained silent while a peer spoke" (p. 536). Baxter et al. noted that the low achievers were usually the audience rather than participants in class discussions. Also, as listeners in class discussions, the target students were often "off-task". A major challenge for low-attaining students was that they could not follow the arguments or strategies presented by fellow students. Baxter et al. concluded that low-attaining students lacked the cognitive and social skills to participate effectively, as either speakers or listeners, in class discussions.

Burns and Myhill (2004) studied the participation of children in Year 2 and Year 6 during 54 teaching episodes. They suggested that the "learning benefits" of whole class discussion were different for different groups within the class in that "positive observable interaction behaviours, most likely to support learning, are engaged in most frequently by high achievers and girls, whereas being off-task is associated more strongly with underachievers and boys" (p. 33). Burns and Myhill concluded that "the findings from this study suggest that, in general, teacher discourse in whole class teaching provided limited opportunities for pupil learning" (p. 24). So while Baxter et al. (2001) concluded that it was student contributions that low-attaining students found difficult to understand, Burns

In V. Steinle, L. Ball & C. Bardini (Eds.), Mathematics education: Yesterday, today and tomorrow (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia). Melbourne, VIC: MERGA.
© Mathematics Education Research Group of Australasia Inc. 2013

and Myhill found that these students also had difficulty with teacher discourse in whole class discussion.

With older seventh-grade students Lubienski (2000) found that the students from lower socio-economic backgrounds claimed that teacher-directed discussion was easier for them to understand. Higher socio-economic seventh-grade students in her study were able to use student-led whole class discussion to clarify, question and potentially advance their mathematical understandings. In contrast, low SES students found such discussions less helpful as the discussion exacerbated their confusion and led to feelings of disempowerment. In Australia Sullivan, Mousley, Zevenbergen and Turner-Harrison (2003) similarly warned that the ability to comprehend classroom discussions can be inhibited by cultural or socio-economic factors. For example, students with a lack of familiarity with standard English were less likely to be able to "crack the code" of language used in whole class mathematics discussions.

There is limited evidence in the literature of whole class discussion being effective for scaffolding the learning of low-attaining students. Empson (2003) reports a teacher's success in improving the participation in whole class discussions and learning of fraction concepts by two low-attaining students, Patrick and Pho. Over 15 lessons the low-attaining students "made productive contributions" (p. 318) on 18 instances. Empson reports that "it was not unusual for [the teacher] to scaffold Patrick's or Pho's solution to a problem and then position them as authorities on these strategies for the group" (p. 318). Staples (2007) also described a lower attaining ninth-grade mathematics class in which the students were successfully involved in collaborative inquiry through whole class discussion. The teacher employed particular instructional strategies such as "eliciting student ideas, scaffolding the production of student ideas, and creating contributions" (p. 177). Staples particularly described the teacher "pressing" the students to articulate their thinking reporting, "Her press was a well-balanced mixture of commitment and pressure, indicating to the student that she valued what he had to say while also indicating that he was expected to articulate or further explicate his thought" (p. 179).

It is clear that there is debate in the literature regarding the worth of whole class discussion for low-attaining students. While many studies have shown whole class discussion to be less effective for low-attaining students than higher attaining students, some demonstrate success, though this appears to be dependent upon the particular skill of the teacher (Empson, 2003; Staples, 2007). My study enters the debate on the efficacy of whole class discussion to scaffold the learning of low-attaining students and adds to this literature by providing a description of the experiences of low-attaining students in whole class mathematics discussions.

Method

The present study was a case study that examined the responses of four low-attaining target students, two each from two different Year 5 and 6 classrooms, to three particular scaffolding practices; the use of discussion, the use of materials and representations and the explicit attention drawn to concepts (Ferguson, 2012). 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 study reflected the latter definition.

Case study as a research methodology was chosen for the present study as there is little research to date on low-attaining students and scaffolding, including through whole class

discussions, and case studies can offer a starting point for research as they contribute findings, issues and observations that arise from the participants' experiences (Merriam, 1998). In addition case studies can offer teachers and educational researchers real examples of classroom experiences.

Participants

Carl and David were in Year 5 and operating about 12 to 18 months below expected levels in mathematics according to the *Victorian Essential Learning Standards* (Victorian Curriculum and Assessment Authority, 2006). They were the target students in Ms B's class who had five years of teaching experience. Sophie, a Year 5 girl, and Riley, a Year 5 boy, were both operating at about 12 months below expected levels in mathematics and were target students in Ms L's class. Ms L had eleven years teaching experience.

Data collection and analysis

Though a number of data collection procedures were employed in the research, data from only some of these are drawn upon for this paper. 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. In this way, data regarding possible cognitive development and affective factors were collected. Data reported here regarding the teachers were drawn from interviews with the teachers prior to the observation period, interviews before and after observed lessons, audio recordings of each lesson and observation notes.

Lesson observations occurred over six 70 to 80 minute mathematics lessons in one week 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. The lesson structure was the same in both classrooms and followed the current curriculum advice at the time which was that "teachers use a range of flexible student groupings … including whole class focus, small groups, independent activities and whole class reflection" (Victorian Curriculum and Assessment Authority, 2006). This lesson structure of beginning and ending lessons with whole class discussions occurred in both research classrooms for all observed lessons.

Data from interviews and lessons were transcribed and detailed lesson observation notes written for each observed lesson. These data were managed 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. I 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

Both Ms B and Ms L used discussion as a significant and regular part of their mathematics lessons both at the beginning and end of each lesson. The data reported here pertain to whole class discussions at the end of lessons as these seemingly were linked more to student learning than beginning of lesson whole class discussions which were often short instructions.

Despite both teachers using whole class discussions, the characteristics of these discussions varied between the two classes. All the end of the lesson whole class discussions observed in Ms B's classroom centered on students sharing their solutions or strategies whereas Ms L tended to use these discussions to preview future lessons, to gauge affective responses or to assign homework. In both classes, the teachers did most of the talking, however in Ms L's class, students said no more than 4 words at a time apart from one example when Riley, a target student, said 44 words, as discussed later in this paper. I will now examine whole class discussions in each classroom focussing on the responses of the low-attaining target students.

Ms B's whole class discussions were characterised by a number of exchanges where Ms B would ask some individual students to explain their thinking in front of the whole class. These exchanges were often quite complex as illustrated by the following example:

Ms B: Now it got a little bit trickier here didn't it? What fraction of the blue rod is the dark green rod? Can you talk us through your strategy Greg? 'Cause that was quite interesting. It was quite similar to the strategy that John was doing.

Greg: I got the blue rod and the ones of the MABs then actually put the blue rod with it and it was nine little rods of the MABs then I measured the dark green one and it was six, so I knew it was nine.

Ms B: Okay so you actually worked out that nine of the little individual blocks made up one of the wholes so you knew each of parts had to be a ninth didn't you?

Greg: Yep

Ms B: How many ninths … obviously it would be nine ninths in the whole, how many ninths was the green one?

Greg: Six

Ms B: So there were six ninths in the green one. Now John what did you do after that? Remember we talked about it didn't we?

John: Then you break them up into three groups of three, then they're thirds.

This exchange is quite difficult to follow, and I believe particularly low-attaining students would find it challenging to understand the strategy described. This section of the whole class discussion was also quickly followed by a different student describing their strategy. In all, for this particular whole class discussion of 15 minutes duration, nine students shared their strategies at Ms B's request. This fast paced discussion where many students briefly shared their strategy or thinking was typical of end of lesson whole class discussions in Ms B's classroom.

The low-attaining target students in Ms B's classroom were each asked once to contribute to the end of lesson whole class discussions over the six lessons. David was invited to explain his strategy for a fraction task.

Ms B: David you had a really good strategy for working it out.

David: I did…um

Ms B: Can you remember?

David: I… I….

Ms B: You found the one that fit on the end to make the whole. . You had the blue one and the green one and you actually found the one that fit here. (Holding up rods and indicating to the gap on top of the green rod) What did you discover

about this rod?"

David: It was a third… no… half.

Ms B: It fit … yeah it was a half of that rod wasn't it. So then you knew it was three equal parts then you knew it was two thirds. That's fantastic thinking.

Here we can see that Ms B was attempting to involve David in the discussion by inviting him to share his strategy. However, David seemed to find articulating his strategy difficult and so Ms B provided the explanation for him, not "pressing" him to persist as Staples (2007) described. Baxter et al. (2001) also described the efforts of a teacher to encourage participation of low-attaining students in whole class discussions, only to find that they were unable to articulate clearly what they had done or thought.

Carl and David were observed engaging in off-task activities during four whole class discussions. This included colouring the answer sheet green or tearing up the answer sheet, putting their heads down, throwing objects or playing with cards. Twice Carl was observed watching the teacher or the board and once both David and Carl watched the teacher. This suggested that for about half of the concluding whole class discussions, David and Carl were not participating either as listeners or speakers. This is similar to findings of Burns and Myhill (2004) who found underachievers and boys tended to be off task more often than high achievers and girls.

It is difficult to attribute learning to end of lesson whole class discussions when these formed only part of the lessons observed in each classroom. However, there were instances in Ms B's class where the end of lesson discussion touched on an area that also formed part of my post-lesson assessment tasks with David and Carl. For example, David and Carl had difficulty matching some fractions with percent or decimal numbers in a post-lesson interview despite the very same numbers being used directly before the interview during the whole class discussion. Ms B had led a discussion about one quarter being equivalent to 0.25 and also 25 percent and then how this related to three quarters being 75 percent. Minutes later, when the lesson ended, I asked David and Carl separately to match some fractions with percent and decimal numbers. My notes were as follows:

> I asked David again why then did ¼ and zero point two five match. David said "because there's 0.25 in a quarter". I then asked him to find a match for 75%. He was silent for 20 seconds. When I asked "not sure?" he said "yeah". (Post-lesson interview)

> I then asked if Carl could find a match for ¼. Initially he said "Nuh!" Then found 1/10 and said "That". I asked him why they matched and he said "because 1 goes into 10 ten times so it's a quarter." (Post-lesson interview)

For both the target students, the whole class discussions did not provide sufficient scaffolding to enable them to complete the post-lesson assessment task successfully. Again, I recognise that the pace at which Ms B moved through important points, such as one quarter being equivalent to 0.25, could have made it difficult for Carl and David to come to understand the relationship between these numbers. This would suggest that end of the lesson whole class discussions might have been confusing and difficult to follow for Carl and David, just as Baxter et al. (2001) found for the low-attaining students in their study.

In the other research classroom, Ms L conducted whole class discussions that differed from discussion in Ms B's class in that student contributions did not feature as heavily and Ms L did much of the talking. Ms L reviewed the lesson, occasionally asked students to indicate their feelings regarding the lesson, pointed to future directions or lessons, linked the lesson to real life and briefly asked some students to share their solutions.

Ms L: Okay guys. Well done. Hands up if you would give yourself a red traffic light? Didn't think so. Yellow? (Riley put up his hand) and green? Can I say that what we need to think about now, it's great to be able to multiply 2 digit by 2 digit numbers using a range of strategies – well done. But would these same strategies work if we were doing 3 three by 2 digits or 3 digits by 3 digits? Would they work in all situations? And it needs to be efficient and do-able. And would these methods that you've trialled be good to use all the time? If I was out shopping and I was going to buy 2 cars for $18 920 each what method would I use probably? … So you don't want to always be using paper and pencil. So we're looking for an efficient strategy that would work in all situations regardless of the numbers. In the classroom sure I'm giving 2 by 2 digit numbers but in the real world that 2 by 2 digit doesn't always exist. That's why I don't sit and write 50 sums on the board for you to do because that doesn't happen in real life. Let me tell you, it doesn't.

The target students Sophie and Riley sat quietly during the whole class discussions. Sophie was not observed contributing to any of the whole class discussions. Riley contributed notably once, when students were asked to find some possible arrangements of equal rows for 60 plants in a vegetable garden. Riley explained to the class that halving one side of a multiplication expression necessitated the other side "going up":

Ms L invited students to share their solutions. Riley put up his hand up.

Riley: I did two. 6 times 10…

Ms L: Okay can you give it to me in rows? Because we are planting my veggie patch here.

Riley: 6 rows on top and 10 down.

Ms L: Hold on. Can I have 6 rows on top and 10 down? What do you mean?

Riley: Like this [showed board]

Ms L: Yeah do you think it's enough to just say 6 rows of 10?

Riley: Yeah and my other one is 20 by 3.

Ms L: So 20 rows of 3.

Riley: Yeah because I just half 6 it would be 3 but when I halve 6, that needs to go up [pointed to 10]

Ms L: Ooh. Excellent. We can put that on another rule. What Riley just said was I have six rows of 10 so if I halve my 6 to 3 the amount of plants in each row will go up. So he's doubled that.

There were no other instances from this lesson or others observed, of Riley or Ms L exploring this concept of doubling and halving.

This episode was the longest utterance during a whole class discussion observed by the target low-attaining students in both classrooms and across all observations. Just as Baxter et al. (2001) found, all other contributions were not more than four words long. This was true of Carl, David, Sophie and Riley, though other students contributed longer responses.

Discussion and implications

The responses of the target students to whole class discussions differed somewhat in the research classrooms. In Ms B's class, for half of these whole class discussions Carl and David were observed engaged in overtly off-task behaviour. Each made one contribution in total during the six concluding discussions observed. Perhaps, as Baxter et al. (2001) suggested, the difficulties that particularly low-attaining students may have in interpreting other students' contributions, could have led to this disengagement by Carl and David. These whole class discussions may have in fact become for Carl and David, "a stimulus for confusion" as described by Ball (1993). In Ms L's class Sophie and Riley usually appeared attentive. Sophie was not observed contributing to these whole discussions, while Riley contributed twice over the course of the six lessons. However, it is difficult to conclude whether Sophie and Riley were listening or simply waiting quietly for the discussion to end. Perhaps Sophie and Riley found their more teacher-directed discussions easier to

follow, as Lubienski (2000) suggested, than did Carl and David, in whose class discussions student contributions were employed more.

The findings of this study, as well as others reported here have implications for teachers who are advised to use whole class discussion at the beginning and end of mathematics lessons (e.g., Victorian Curriculum and Assessment Authority, 2006). If teachers seek to follow this advice, much of mathematics lesson time will be devoted to whole class discussion. However, there is evidence to suggest that whole class discussions for low-attaining students might be a waste of time, as Ball (1993) warned.

The literature provides teachers with some advice on how to maximise the effectiveness of whole class discussions for low-attaining students. Baxter et al. (2001) proposed that teachers could improve the participation of low-attaining students in discussions and make such discussions beneficial to learning mathematics. One suggestion was that the teacher provided some kind of summary statement after students have shared strategies, which highlighted two or three of these strategies. This narrowing of the focus to just a few student strategies may have benefitted Carl and David in Ms B's class who heard as many as nine different student contributions in one discussion. Sullivan, Mousley and Zevenbergen (2004) added to this by advising the teacher to record the main points of the discussion for display and rephrase the responses of students to enable low-attaining students to access and engage in the discussion. The *Improving Attainments in Mathematics Project* (Watson, De Geest & Prestage, 2005) investigated how teachers could improve attainment for low-attaining students through the use of practices aimed at improving student thinking. Regarding whole class discussions, this project found that successful strategies were students writing on the board or overhead projector to share their ideas, the teacher writing everything that students say on the board for later discussion by the class and encouraging participation by establishing "hands down and think" time during discussions after which any student may be asked to contribute. In addition, all students should be explicitly taught about the purpose of whole class discussions, for example to learn from each other, and their role in such discussions such as critically listen to other students' contributions (Sullivan et al., 2003).

I believe that one of the most pressing areas for future research that arose from my study was the issue of whole class discussions in mathematics classes and low-attaining students. Whole class discussions remain a potentially rich learning opportunity for students to recognise and consider other students' strategies and thinking as well as articulate, and thereby clarify, their own. Low-attaining students should not be excluded from these benefits. However, teachers need to employ pedagogical techniques, such as those identified above in this paper, to facilitate low-attaining students accessing and participating in whole class discussions. The teachers in my study spent significant amounts of time in whole class discussion but the question remains as to whether this was time well spent for the target low-attaining students. Perhaps, as well as using particular pedagogical strategies during whole class discussions, less time might be spent on whole class discussions. As discussed in Ferguson (2010) individual "scaffolding conversations" were more effective in the present study than whole class discussions. If whole class discussions were shorter and focussed, more time could be spent creating opportunities for teachers to provide these more effective scaffolding practices that better support the learning of low-attaining students.

References

Ball, D. (1993). With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. *Elementary School Journal, 93*(4), 373-397.

Baxter, J., Woodward, J., & Olson, D. (2001). Effects of reform-based mathematics instruction on low achievers in five third-grade classrooms. *The Elementary School Journal, 101*(5), 529-547.

Burns, C., & Myhill, D. (2004). Interactive or inactive? A consideration of the nature of interaction in whole class teaching. *Cambridge Journal of Education, 34*(1), 35-49.

Cazden, C. (1988) Classroom Discourse: The Language of Teaching and Learning. Portsmouth, NM: Heinemann Educational Books.

Chapin, S. H., O'Connor, C., & Anderson, N. C. (2003). *Classroom discussions: Using math talk to help students to learn, grades 1-6*. Sausalito, CA: Math Solutions Publications.

Empson, S. (2003). Low-performing students and teaching fractions for understanding: An interactional analysis. *Journal for Research in Mathematics Education, 34*(4), 305-343.

Ferguson, S. (2012). Like a bridge: Scaffolding as a means of assisting low-attaining students in mathematics during cognitively challenging tasks. Unpublished doctoral dissertation, Australian Catholic University, Melbourne.

Ferguson, S., & McDonough, A. (2010). The impact of two teachers' use of specific scaffolding practices on low-attaining upper primary students. In 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, pp. 191-198). Fremantle: MERGA.

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

Hiebert, J., & Wearne, D. (1993). Instructional tasks, classroom discourse, and students' learning in second-grade arithmetic. *American Educational Research Journal, 30*(2), 393-425.

Inagaki, K., Hatano, G., & Morita, E. (1998). Construction of mathematical knowledge through whole-class discussion. *Learning and Instruction, 8*(6), 503–526.

Lubienski, S. T. (2000). A clash of social class and cultures? Students' experiences in a discussion-intensive seventh-grade mathematics classroom. *The Elementary School Journal, 100*(4), 377- 403.

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

QSR International. (2005). *NVivo*. Doncaster, Victoria: QSR International Pty Ltd.

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

Staples, M.H. (2007). Supporting whole-class collaborative inquiry in a secondary mathematics classroom. *Cognition & Instruction, 25*(2), 161-217.

Sullivan, P., Mousley, J., & Zevenbergen, R. (2004). Describing elements of mathematics lessons that accommodate diversity in student background. In M. Høines & A. Fuglestad (Eds.), *Proceedings of the 28th conference of the International Group for the Psychology of Mathematics Education* (Vol. 4, pp. 257-264). Bergen: PME.

Sullivan, Mousley, J., Zevenbergen, R., & Turner-Harrison, R. (2003). Being explicit about aspects of mathematics pedagogy. In N. Pateman, J. Dougherty & J. Zilliox (Eds.), *Proceedings of the 27th annual conference for the International Group for the Psychology of Mathematics Education* (Vol. 4, pp. 267-273). Honolulu, HI: PME.

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

Watson, A., De Geest, E., & Prestage, S. (2005). Principled teaching for deep progress: Improving mathematical learning beyond methods and materials. *Educational Studies in Mathematics, 58*(7), 209-234.