Teaching as Listening: Another Aspect of Teachers' Content Knowledge in the Numeracy Classroom

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Recent mathematics education reform calls for pedagogical practice that is responsive to students' personal articulations of mathematics ideas. In such initiatives, listening to students is fundamental to advancing students' thinking. Our study explored the relationship between teachers' orientation towards listening and teachers' content knowledge. We investigated how four teachers listened to and made sense of students' ideas, and the influence of content knowledge on their capacity to listen. The study revealed that the depth of teachers' content knowledge – both subject matter knowledge and pedagogical content knowledge – mediated their enactment of effective listening practices.

Content knowledge plays a key role in teacher effectiveness (Ball & Bass, 2000). What teachers do in classrooms is very much influenced by what they know about mathematics (Hill, Rowan, & Ball, 2005; Shulman, 1986). The effective teacher has a sound grasp of mathematical ideas (Askew, Brown, Rhodes, Johnston, & Wiliam, 1997), and from that understanding is able to choose appropriate ways to represent subject matter, to ask questions, to plan activities, and to facilitate discussions. Importantly, a high level of content knowledge provides teachers with the cognitive resources that enable them to move students' thinking forward. Teachers do this by negotiating their understanding of subject matter with their knowledge of the learning of the students in the classrooms (Sherin, 2002). We were interested to see if teachers' subject matter knowledge and knowledge of pedagogical content also influenced the ways in which teachers listened to students.

Careful listening to what students have to say has been shown to be an important aspect of practice (Carpenter & Fennema, 1992; Crespo, 2000; Davis, 1997). Unlike traditional classrooms, in which there is little opportunity for students to engage in extended dialogue about mathematics (Tanner, Jones, Kennewell, & Beauchamp, 2005), teachers in classrooms implementing new initiatives hold the view that talking about mathematics is an essential feature of a quality mathematical experience. Muir (2006) suggests that "encouragement of purposeful discussion" allows teachers to "probe and challenge children's thinking and reasoning" (p. 369). Purposeful mathematical discussion, however, demands focused listening. Effective teachers who listen carefully to students' responses to questions are able to draw out students' understandings (Yackel, Cobb, & Wood, 1990). Franke and Kazemi (2001) have shown from their research that, not only is listening important but also it is fundamental to advancing students' thinking. It is, according to Sherin (2002), one of the key focus areas for initiating more effective mathematics teaching. Indeed, for teachers in research undertaken by Carpenter and Fennema (1992), "listening to their students was the crucial factor" (p. 463) that contributed to more effective mathematics instruction.

Teachers listen to their students through their own mathematical, personal, and social resources (Wallach & Even, 2005). Teachers who do not listen or do not understand their students' thinking, tend to minimise or dismiss it, by imposing their own understandings (Cobb, 1988). Ball (1997) has argued that a teacher's understanding of the subject matter, along with the commitment to the students in the classroom, will significantly influence what the teacher hears. Hill, Rowan, and Ball (2005) go so far as saying that knowledgeable teachers are able to hear their students' methods better because they have a clearer understanding of the structures and connections of mathematics. Teachers with sound content knowledge are able to access the conceptual understandings that students are articulating. They are able to make informed decisions about how those understandings might have arisen and where they might be heading (Shulman & Shulman, 2004). Such teachers listen by drawing on their content knowledge in order to create "more powerful forms of classroom teaching" (Doerr & Lesh, 2002, p. 130).

Conceptual Framework

In our exploration of the relationship between listening and content knowledge we have found the work on communities, developed by social practice theorists, extremely helpful. Lave and Wenger (1991), amongst others, propose that people develop knowledge when they are engaged in immediate, concrete, specific, and meaning-rich activities. What their proposals are able to explain is how learning occurs in the context of shared events and interests. We draw on these ideas about communities of practice to explain an aspect of classroom teaching. We plan to show that the way in which students' understandings of mathematics are advanced within the classroom community is very much influenced by what the teacher hears. In turn, what the teacher hears is informed by his/her content knowledge.

Our analytic strategy is guided by the categories set out by Davis (1997). Davis' three categories of teachers' orientation to listening have proved to be an effective means of understanding classroom phenomena. The conceptual categories are namely, evaluative, interpretive, and hermeneutic. Davis suggests that not all forms of listening are conducive and respectful of students' thinking. For example, teachers with an *evaluative* orientation tend to listen to students' ideas in order to diagnose and correct their mathematical understandings. A correct answer is already in place in the teacher's mind (Crespo, 2000). Typically, if the expected response is not given by the students then often the gaps would be filled by the teacher's response. Thus the teacher strives for unambiguous explanations and to maintain a well-structured lesson that does not deviate.

Teachers with an *interpretative* orientation listen to a student's ideas with the primary purpose of assessing. In relation to the evaluative orientation, there is an increased opportunity for interaction, both between teacher and student, and among students. However, the teacher is accessing rather than assessing the student's understanding (Crespo, 2000). There is an awareness of active participation. However, what is learned is manageable for the teacher within a set of precise steps in order to achieve particular pre-specified understanding. Teachers with a *hermeneutic* orientation continually and interactively listen to a student's ideas. They tend to adopt a more flexible approach to the ever-changing circumstances within the learning process by engaging with them in the "messy process of negotiation of meaning and understanding" (Crespo, 2000, p. 156).

Our interest in these categories of teachers' orientations to listening was to explore the influence of teachers' content knowledge on each. We wanted to investigate the teachers' approach to listening within the classroom as an enactment of their content knowledge.

Attending to teachers' orientations to listening will help us understand effective practice (Davis, 1997).

Description of the Study

We report on the second year of our study on "Teacher Knowledge". The study is one of four research "nests" situated within a larger project, *Numeracy Practices and Change*. The New Zealand Numeracy Development Project (Ministry of Education, 2001) acknowledges that:

> teachers' understanding of subject matter and of pedagogy are critical factors in mathematics teaching. The effective teacher has a thorough understanding of the subject matter to be taught, comprehends how students are likely to learn, and knows difficulties and misunderstandings they are likely to encounter. (p. 2)

The Numeracy Development Project provided the context for our focus on teacher knowledge. In our first year of study we reported on teachers "learning to notice" critical mathematical instances during classroom interactions (Davies & Walker, 2005). The focus of our second year was to move from the supportive community of learners to a closer investigation of the teachers in their classrooms. In order to characterise how content knowledge is enacted we further investigated teachers on the process of noticing significant mathematical moments. This paper reports on one central aspect of teachers noticing, namely, their orientation towards listening. The questions guiding the exploration were as follows:

- Was there evidence of different orientations to listening?
- Did the orientation to listening affect the lesson pathway?
- Was there a link between teachers' content knowledge development and their listening?

To address those questions we used a design research experiment working collaboratively with four teachers from two primary schools. The nature and design experiment methodology allowed us to investigate further classroom incidences of "listening" and the teachers reflection on these incidences. We report here on two teachers, whom we name Mike and Joe, from the same school, both of whom focussed on the topic of fractions for their year 5/6 classes. Initially the teachers were released from their classrooms for a brainstorming/planning session with the researchers. This session focussed on possible teaching points, key fraction understanding, as well as problems and equipment. Within this session teachers' own content knowledge was discussed.

Extensive use was made of video footage recorded by the researcher in each class on five occasions over a two-week period. Following each recording, the teacher was released to view video footage and participate in reflective discussion with the researcher. Teachers were asked to stop the video at significant mathematical moments and discuss. Initially this discussion was to focus on simple questions, such as: What did you notice? What does this mean? However, it soon became apparent that teachers were not noticing key mathematical moments themselves when watching the video footage. As researchers we drew out significant mathematical incidences and refocused our attention on instances of teachers' "listening".

Audiotapes were used to record each reflective session with the teacher, during the time that the video footage of their teaching was reviewed. The video footage of teaching and the resulting audiotapes of discussion, together with researcher's field notes, formed the dataset. At the end of the research period individual interviews recorded on audiotape were transcribed and collated. Relevant excerpts from these were analysed for anecdotes of listening and comments regarding mathematical incidences. Video footage was replayed to transcribe exact instances of listening and resulting teaching and learning pathways.

Results and Discussion

The discussion is developed around two teaching episodes that are drawn from Joe and Mike. Each is intended to highlight moments from a teaching episode characterised by a particular orientation to listening. The purpose of the selection and discussion is to identify, describe and contrast some classroom episodes during which significant mathematical incidences occurred. These classroom episodes illustrate how "listening orientations" can be useful analytic tools for interpreting classroom phenomena and as a starting place for transforming mathematics teaching practice.

Through the extensive use of video in the first year of research teachers "noticed" aspects of their teaching. After viewing his teaching, Joe commented on the types of questions he asked. Joe clarified his need for "better questions".

> Because in a lot of ways, my questioning was directly leading the student to the right answer, I was in some ways influencing their answer and it wasn't giving them a chance to think about the answer and get the right answer, rather than giving it to them. … Asking better questions and more open-ended questions. So why did you think that?

He was aware of the need to follow the student's response and, if needed, to make significant changes in the direction of the lesson. Making changes involves both in-depth subject knowledge and pedagogical content knowledge. In the second year of research Joe again spoke about using questioning to "get inside" the children's heads. This pointed to an effort, on his part, to use a more interpretive approach to listening. In the following problem that Joe gave his class, we track how this happened.

> Amy earns $24 a week. She saves 1/3. She keeps ¼ for clothes, ¼ for hobbies and movies and 1/6 for junk food. How much does she spend on each?

Joe moved around working with small groups of children.

Joe:	Saves 1/3, how much is that?
Child:	8 dollars
Joe:	Great, how did you work that out?
Child:	3 times 8 is 24
Joe:	And you took that away? Good girl.
Joe:	She keeps ¼ of this for clothes. So she keeps ¼ of 16 for clothes
Child:	4 dollars
Joe:	Good, we've got 4, we take 4 away from 16
Child:	12
Joe:	Put the 12 dollars down, once again we've got a ¼ for hobbies … [continues subtracting from total] …
Joe:	We have 9 dollars and she spends 1/6 on junk food …[pauses… rechecks question] … I'll check I have the question right. Wait there.
Comments to researcher:	That's quite hard aye?

Later the class came together to share their solutions and Joe selected Jordan to share his solution.

Joe:	Some people have done it quite differently than how I did it, which is fine. Tell us what you did Jordan.
Jordan:	Well 1/3 of 24 is 8 cause 8 times 3 is 24
Joe:	Yes, did everyone else get that?
Jordan:	Then ¼ for clothes is 6, and so ¼ for hobbies is the same 6, and 1/6 for junk food is 4. [Looks to teacher for support, teacher nods to carry on]
Jordan:	So then 6 plus 6 plus 4 is 16.

Jordan sits down and Joe looked slightly puzzled; not actually convinced of Jordan's thinking.

Joe:	Who got the same answer as Jordan? Who had a different answer? I know I did. But we were doing the same stuff though. As we went through each step I took that money away from the total. Just goes to show that the way you interpret the question can affect your answer.

Joe seemed not to consider the solution suggested by Jordan. He was not attending to the answer given in a way that would help develop understanding. Davis (1994) warns that the listener must be "vigilant to the fallibility of interpretation" (p. 279). Initially Joe worked out the problem and when it proved difficult to solve he thought perhaps he had written it incorrectly. Jordan managed to solve the problem as presented; however, his thinking did not match Joe's. In the discussion that followed the video Joe described his thinking.

Joe:	I was comfortable with that. The group that came to the board had a 1/3 of 24 and then ¼ of 24. They were not using takeaway and decreasing amounts.
Researcher:	Why do you say takeaway?
Joe:	Because that is what she spent, its obvious, she is spending the money so you take it away. [long pause]
Joe:	Now I look back on it, they answered the way it was meant to be. The question wasn't well written though was it? When you think of money you take some away for savings and then you deal with what you have left!

Joe was listening through his own mathematical, personal, and social resources (Wallach & Even, 2005). His subject matter knowledge influenced what he heard as he was unable to access the conceptual understanding that Jordan was articulating (Hill et al., 2005). As an evaluative listener, Joe was seeking a particular response; even though the child's response provided a solution to the problem he did not change his thinking. His own content knowledge let him down.

Two days later Joe gave two similar problems to a group and worked alongside the children as they solved them. In the first problem there were 32 children choosing their favourite sport: ¼ rugby, 1/8 tee ball, etc. The problem solution was discussed and solved satisfactorily. The second problem involved 60 vegetables for an "umu": ¼ were taro, ¼ kumara, 1/3 yams, and 1/6 breadfruit. Joe worked with the children individually questioning their workings and requiring explanations. He confirmed Sam's solution of 15, 15, 20 and 10. When sharing his strategy Sam explained he found a quarter through halving the 60 and halving again. Sam then drew 6 dots to represent the 60 vegetables and proceeded to use the dots to simplify finding a third, by circling two dots, and then a sixth by circling one dot. However Joe took over Sam's explanation using his subtraction method to the obvious confusion of Sam. During the reviewing of the video Joe explained,

> Yeah I saw on his paper he had done it all right but he lost me a bit [when explaining on the board], so I wanted to come back to the point where I knew where he was and that's where I went wrong … I was trying to make Sam think how I was thinking and not getting inside his head.

Although similar problems had been fully explored with both the researcher and through the explanations of some children, Joe continued with his misconception. Joe was listening for the response he wanted. Joe needed to take the child to where Joe could understand and move the solution on the expected pathway. In an effort to "get inside the child's head" and to diagnose and correct the child's understanding he used an evaluative orientation to listening seeking a common understanding. Joe was limited by his content knowledge unaware of the fallibility of his own method.

We now move to our second teacher Mike. On the final day videoed, Mike provided a group with a variety of circular fraction pieces to investigate and to make five statements about them. Mike's expectation was that they would come back with equivalent fractions although he did not communicate this to the group.

> Statements from this group shared with the rest of the class included:
> 1/3 and 1/6 makes a ½
> 2 ¼'s makes ½
> 4 of 1/8's makes a ½
> 1/6 and 1/8 makes ¼.

During the review of the teaching episode Mike explained that although his plan was to focus on equivalent fractions due to the "novel student responses" involving addition he decided to follow the children's lead. A noticeable difference was the increased opportunity for interaction within the group. Mike opened up opportunities for representation and revision of ideas (Davis, 1997). He was surprised that the children were capable of working things out for themselves even though it was not quite what he expected. He said that for them, it was valuable learning. Mike's listening orientation moved to a more interpretative stand.

The teaching continued as he decided to open the discussion to the rest of the class. Once again he deviated from his initial plan indicating a more interpretative approach. After further statements about the circular regions he asked if anyone could make any statements about adding fractions. Within this discussion Mike moved from interpretive listening back to evaluative listening.

> George made the statement 1/3 + 1/6 + 1/3 + 1/6 = 1 whole [Mike wrote this on the board].
> Mike asked could anyone make it a shorter equation.
> Teane wrote ½ + ½ = 1
> When asked to explain this Teane said 1/3+1/6=1/2 [Mike did not seek further explanation].
> Bridget wrote 2/6 + 2/12 = 1 and explained it pointing the 2 1/3's were the 2/6 and the 2 1/6 were the 2/12.

At this stage we see Mike constructing with the learners as they construct their mathematics (Davis, 1997). He was accessing the children's understanding in an interactive way. His purpose of accessing rather than assessing the children's thinking demonstrated an interpretative orientation to listening (Crespo, 2000). He continued,

> Mike asked what the "rectangles group" had learnt when discussing adding fractions in their group?
>
> Child: Not allowed to change the denominators [i.e. not adding them together]
> Mike to Teane: You're not even in that group well done [acknowledges Teane's earlier response].
> Mike to Bridget: I am banning you changing the denominator but if you can change the numerator what would it look like now?
>
> Bridget rubbed out the 6 [in 2/6] and changed it to a 3 [looked for reassurance] then changed the 12 [in 2/12] to 6 and quickly sat down. [She now had 2/3 + 2/6 = 1]

Mike: OK who agrees with the equation Bridget has made? [quick show of hands].Can you explain Bridget why it's true?
Bridget: Cause I didn't change the denominators.
Mike: OK gonna stop there guys cause the bell is going to go but it's certainly something to discuss for next time.
George [quickly said]: That it was the same as 2/3 + 1/3 = 1.

Mike's reliance on procedural mathematics understanding influenced his teaching and his listening orientation. Bridget gave the wrong answer so he gave her a way to fix it and then moved on. Mike was comfortable with George's equation as it demonstrated procedural understanding, which is how Mike operates. George was also one of the children he considered to be good at mathematics. Davis (1994) suggests teachers' orientation to listening is enabled by "who" the teachers are listening to and constrained by "what" they are listening for. During discussions whilst viewing the video Mike commented that he asks George to explain further because he expects a correct response. But he did not ask Teane because Mike thought that he would not be able to explain satisfactorily. Mike began to question his view on Teane's ability after watching the video.

Mike demonstrated a shift from a strong evaluative orientation to listening to the beginnings of an interpretive orientation. However his own procedural understanding and his expectations of children's ability greatly influenced what he heard the children say (Crespo, 2000). It also influenced how he reacted to it drawing him back to a more evaluative orientation.

Conclusions

To teach effectively it is crucial that teachers notice the significant mathematical moments and respond appropriately. If teachers are going to provide students with appropriate mathematical challenges and assist the students to gain meaning, they need to be able to access their own content knowledge whilst engaged in the act of teaching. We expected that a novel student idea would prompt the teachers to reflect on and rethink their instruction (Schifter, 1996). The teachers did initiate questioning and probing in order to assess the students' understanding. To do this they needed to listen to the students' ideas and access their own content knowledge complexes to decide how best to proceed. However the teachers, more often than not, return to their planned lesson rather than exploring the students' ideas. Attention was given to the students' responses with little impact on the development of the lesson as the teacher was only seeking a particular response. Davis (1997) calls this evaluative listening.

It was apparent throughout the 2 years of our research that teachers' orientations to listening varied greatly between individuals and also within lessons. The orientation to listening influenced their ability to negotiate the lesson fully. Their listening orientation was dependent upon the level of their own content knowledge (Ball, 1997). We suggest that the teachers did not have the knowledge of the subject to be able to make connections for the children and for themselves. Teachers' orientation to listening was also influenced by their expectations of the children's mathematical ability. These expectations influenced their decisions concerning which child to call upon, whether to require further explanation of their thinking, or whether they just filled in the gaps (Crespo, 2000). Perhaps we also need to examine the teachers' beliefs about mathematics. If teachers believe that learning mathematics involves only the "acquisition of knowledge" then their orientation to listening takes on quite a different relevance (Davis, 1994, p. 279).

Noticeably absent from this study was Davis' (1997) third category of hermeneutic listening. We are left to wonder whether this orientation to listening is accessible to teachers without further support and what kinds of experiences might bring about a transformation in their practices. For teachers to realise the need for change and to transform their practice they need a strong community of support (Davis, 1997). Due to the complexities of teaching it is difficult to isolate "quick remedies" in developing more effective listeners. Time needed for change is a constraint. In our first year we saw changes in the teachers "learning to notice" after ongoing intensive planning/content knowledge workshops within a supportive community of learners. The more condensed time frame in the second year did not allow opportunities for ongoing and sustained change (Doerr & Lesh, 2003).

The teachers' content knowledge became a central organiser for the lessons and a defining feature of effective teaching. The depth of teachers' content knowledge – both subject matter knowledge and pedagogical content knowledge – mediated their enactment of effective listening practices.

Acknowledgement: The authors wish to acknowledge that this project was funded through the New Zealand Ministry of Education's *Teaching and Learning Research Initiative (TLRI).*

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