

AUTHORITY RELATIONS IN THE ACQUISITION OF THE MATHEMATICAL REGISTER AT HOME AND AT SCHOOL

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Being able to communicate mathematical ideas is an aim of many mathematical curricula around the world. To achieve this, students need to acquire the mathematics register. This paper uses data from research in which a six-year old child's interactions with others, including her teacher, her peers and her family, were recorded. From one day's recording, initial findings are presented of how authority is manifested in these interactions and the effect that this has on opportunities for the child to acquire the mathematics register. It would seem that how interactions occur in the home are more likely to result in the acquisition of the mathematics register.

INTRODUCTION

In many mathematics curricula, being able to use the mathematics register fluently is seen as important (see Australia Education Council, 1991, NZ Ministry of Education, 2006). Based on the ideas of Halliday (1978), the mathematics register is considered to be the set of terms and grammatical constructions that mathematicians believe are the most appropriate ones for communicating their ideas clearly, succinctly and with the maximum amount of meaning to their listeners or readers. However, the mathematics register including an understanding, of when and how it is to be used, must be learnt (Moschkovich, 2003). This paper reports on research that investigated the opportunities both in and outside school for learning the mathematics register. It uses data from the first day of recording to explore how authority within interactions was manifested and the effect this may have had on the child's learning of mathematical language.

The acquisition of the mathematics register occurs over time and has been considered to consist of four stages (Meaney, 2006). First, students have to notice that there is new language to be learnt. With prompting, students use the new terms and expressions. Gradually the prompting is lessened and students begin to use the terms in a variety of situations. Feedback, both positive and negative, helps them to refine their understanding of when and how to use new aspects of the mathematics register. After students have consolidated their understanding, the terms and expressions are integrated into their linguistic repertoire. Students then use these terms consistently, except when the situation is challenging and they may revert back to less mathematical expressions. The final phase is when students use the terms fluently even in the most demanding situations. Authority for validating the appropriate use of the mathematics register can be expected to reside with the teacher when students are just beginning to learn new aspects of the mathematics register. However, as the students take greater control over when to use it, the teacher's role is one of providing

opportunities for its natural use. The transfer of responsibility in using the mathematics register thus moves from the teacher to the student and can be supported or hindered by the way that opportunities for its use are structured.

Most research about the acquisition of the mathematics register has focussed on what occurs in the classroom (see for example, Chronaki and Christiansen, 2005). Yet, by the time children enter school, they have a significant amount of mathematical knowledge (Young-Loveridge, 1987). By participating in mathematical activities at home, it could be considered that children may also have had opportunities for learning some of the mathematics register. However, this may not be straight forward. Walkerdine's (1988) work suggested that home and school experiences are constituted differently. Although conversations and activities appear superficially to share features so that both can be labelled *mathematical*, the meanings are so different that there is, in fact, little overlap between them. In considering how time is discussed, Walkerdine wrote '[i]n order to operate on the mathematical dimension, the focus has to be taken away from the practical and external relations to the internal relations of the numerical sequence of the measurement of time' (p. 109).

Thus, in comparing how the mathematics register is acquired at home and at school, there is a need to investigate not just whether preference is given to mathematical meaning but how this occurs. This includes looking at who controls the interaction and how they do it. In research about the use of authority to validate what was mathematically appropriate, the teacher was seen as the supreme authority, even though she had verbally tried to dissipate this view (Amit and Fried, 2005). In a study on mathematical explanations, the teacher used her authority to talk over the top of students who did not provide her preferred type of explanation (Forman, McCormick and Donato, 1998). In both studies, it was the teacher who was perceived as having the authority to determine what was valued as mathematics or the mathematics register. Forman et al. (1998) suggested that sociocultural theory, especially that of Bakhtin, proposed that students were socialised into conforming to the forms of academic discourse. They stated that 'students will have to struggle to reconcile their own speaking and thinking with that of the teacher' (p. 316). Consequently, the role of the student could be presumed to be passive. Rogoff (1990), however, showed that a child can have an active role in interactions that result in scaffolding strategies being provided by the adult. Interactions that could lead to students acquiring the mathematics register are affected by two considerations. The first of these is to do with how mathematical meaning is given preference. The second is to do with who controls the interactions and how they do this.

METHOD

This paper uses data from the first day of a case study that investigated a six year old girl's acquisition of the mathematics register both at home and at school. The research child was recorded for one day a week, for twenty weeks, in the second half of 2005. The child's parents are Samoan speakers but English was the primary language

spoken at home. The mother was the research assistant for this study and managed the logistics of recording the child's interactions. From when she woke in the morning until she went to school, the child wore a lapel microphone connected to a digital voice recorder. During her mathematics lesson, she was again recorded and the class discussion captured on another voice recorder connected to a conference microphone. After she was collected from school, the child again wore the voice recorder. Her mother listened to all of the recordings and sent to a transcriber those interactions that appeared to be about mathematical practices. The data for this paper came from the first day of recording.

The transcripts were coded in a number of ways, including identifying the language focus, the language learning stage, and who controlled the situation. In this paper, three pairs of extracts from the classroom and home data are presented.

FINDINGS AND DISCUSSION

The first pair of extracts came from the setting up of mathematical activities. In the classroom, the teacher had written the purpose of the lesson, or the learning intention, on a small blackboard. Extract 2 is from the home and is also about setting up a new board game, *Shrek Operation*. Although the child had been agitating for some time to play it, the decision to do so on that day was the mother's. It is unlikely that the child felt that she was obligated to participate and so the authority for setting up the activity could be considered as shared.

Extract 1

Teacher: What's our learning intention? Let's read it.

Class: I am learning my basic addition facts.

Teacher: If we're doing addition facts, are we adding or taking away? Think about that in your head; turn and tell the person sitting beside you; and stop and listen again. Read our learning intention.

Class: I am learning my basic addition facts.

Teacher: What if I do that? What word have I got?

Class: Add.

Extract 2

Adult: Where's the rules; where's the rule how you're playing?

Child: I don't really know.

Adult: Well, you need the rule book. We need to find it. Oh, I know where it is.

Child: I haven't really set it up yet.

Adult: The object of the game is you have to earn the most money by performing successful operations. Have you got 12 parts?

Child: In how many parts?

Adult: Twelve white bits.

Child: ___ ___ one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve. Done

- Teacher: So if we're doing addition, are we adding or taking away?
- Class: Add.
- Teacher: Adding, ka pai [Māori word for good]. What's the sign that we use? Everybody make the adding sign up in the air with their magic finger; write it on the carpet in front of you; write it on the back of your hand; write it on your palm; write it on your knee; write it on your other knee; write it. So what are we learning to do?
- Adult: See, there are two types of cards [child], look specialist, and a ...
- Right, there are two types of cards.
- Child: Specialist and doctor.
- Adult: Right, start with a specialist card and we'll deal them up face up one at a time so that each player gets the right number, like this. Oh, sorry, so we can get the same amount. Ok, can you count how many you've got?
- Child: I've actually got one, two, three, four, five, six. Six specialist cards.
- Adult: Okay, take any extra cards out of the pile and shuffle the doctor cards, take ___ oh yeah, they have to go over there.
- Child: I haven't actually finished setting this up, I need the book to see what they look like 'cause I'm not good at them, yeah.

Analysis

Language focus:	Addition (definition of and connection to the mathematical symbol)	Amounts (12, 2, 6, same)
Language skills:	Reading, listening, speaking and writing	Listening, speaking (reading by the mother)
Authority:	Teacher	Rule book (as can be seen in comments by both the mother, at the beginning, and the child, at the end)
Negotiation of	None with the teacher having	By reading parts of the rule book, the mother controlled the setting

interaction: complete control

up of the game and so orchestrated preference being given to mathematical meanings ('have you got 12 parts' and 'can you count how many you've got'). The child attempted to circumvent this control by suggesting that if she had the rule book, she could set up the game herself. The authority rested with the rule book but who controlled it was negotiated.

Impact on learning of mathematics register: The way that lesson was organised suggested that the teacher believed that it was new language for the students. Use of all language skills illustrated the connection between them when students interpreted and used 'addition'. Students were invited to connect new aspects of the mathematics register to what they already knew. However, students gave choral responses, thus limiting their opportunities to manipulate what was to be learnt. The teacher was the authority on what was mathematical language and how it should be learnt.

Although the mother had the authority to give preference to the mathematical meanings when she controlled the rule book, she operated as though the child was a competent user of the mathematics register. This is quite different to the classroom example where the teacher used a set of very restrictive questions to ensure that the students used the language appropriately.

Comparison

In the two extracts, the difference is between the type of learning that is occurring. At school, learning is of *what*, in this case addition - how to say it, how to define it, how to write it. The learning at home was more about *when* to use amounts - what contexts do you use them in, why do you use them, how can you control not using them. Both types of learning are needed in order to be a fluent user of the mathematics register. Our data suggests that the classroom interactions tend to do the first type well but the conditions at home also facilitate the second type of learning.

The next pair of extracts are from the middle of activities. Extract 3 began with the teacher asking a series of addition questions to a small group. The questions were written on the whiteboard. Extract 4 is from playing the game. The child was acting as the banker and the interaction was around the need to give money to her mother.

Working Group 8

Extract 3

Teacher: Five plus five.

Students: 10.

Teacher: Four plus four.

Students: 8.

Teacher: What's the special name that we give those? They've got a special name, do you know, A?

A: Double.

Teacher: Double, give a big clap.

Students: (Claps)

Teacher: Wow, double. Who knows another double?

Child: Three plus three plus three.

Teacher: That's triple, because how many numbers did she use?

Child: Three.

Teacher: We're doing doubles, and what do you notice when it's a double? Tell me what you notice about the numbers, to be a double they have to be what?

Child: The same, what the same, and I've got one, 200 plus 200.

Teacher: 400.

Extract 4

Adult: Oh, gosh, yeah, so you have to give me two hundred dollars please.

Child: What, two hundred, what does I have to give you?

Adult: Look on the money, does it say two hundred or what?

Child: I see five hundred and one hundred.

Adult: Well, how much is two hundred from that then.

Child: Oh, so it's donkey.

Adult: One hundred plus, if that's one hundred, I want two hundred, how many do you give me?

Child: Mmm, maybe that.

Adult: How many is that?

Child: Two hundred.

Adult: Good because one hundred plus one hundred is...

Child: Two hundred.

Adult: Yeah.

Child: My turn.

Adult: How much money have you got? Are we a new winner?

Child: I've got only five hundred.

Adult: Oh you're beating me, that's more than two hundred.

Child: Oh

Adult: Five hundred is that much, two hundred is that much. (SHOWING HER) That's all, your turn.

Analysis

Language focus:	Doubles	Amounts and the relationship between them (200, 500, 100)
Language skills:	Reading, listening, speaking	Listening, speaking, reading
Authority:	Teacher	Mother
Negotiation of interaction:	Teacher ensured the focus remained on doubles. However, the children's surprising answers to her more open questions meant that they had the opportunity to explore some of their ideas around this focus. The response of 'three plus three plus three' was clarified by the teacher as not being a valid response. The '200 plus 200' response was surprising because, although it was a double, it was not a basic addition fact.	By following the rules of the game, the mother controlled the interaction. She modified her support after listening to the child's responses. There are parallels with classroom extract in this pair, as the child also gives some surprising responses, 'I've got only five hundred'. The mother, like the teacher, uses these to reinforce the mathematical meaning of 'two hundred'.
Impact on learning of mathematics register:	The students who offered surprising responses possibly gained a better sense of the definition of <i>what</i> a double was.	The learning is related to the child's immediate interest in playing the game. As the banker with an interest in winning, she needed to know what 200 meant in relationship to 500.

Comparison

In both extracts, the learning is concentrated on the *what*, with the authority lying with the adults. The teacher's focus on the doubles as part of a lesson on basic addition facts meant that surprising results were not built on but rather channelled back to the main focus. The context of the game means that the mother's focus becomes that of the child. If the child is to play the game then she must learn the relationship between the different amounts of hundred dollars. It is possible to imagine classroom activities that would also encourage children to have a purpose to learn. However, the one-to-one situation at home allows for the negotiation in the interaction is perhaps not as easily obtainable in a busy classroom of 24 students.

The final two excerpts both come from when the child (RC) worked with a partner in the classroom to complete a sheet of basic facts. The students discussed the equation $10 - \square = 7$. Soon after extract 5, the research child requested help from her mother,

who was in the classroom for the research. As the project continued, the mother often filled the role of knowledgeable adult with other students as well.

Extract 5

Partner: I know that top one. I know.

RC: Yeah.

Partner: It's ten but that one there?

RC: Oh, don't ask me. Mm, 10, 10 two, 10 take away two, ten take away two.

Partner: 1, 2, 3, 4, 5, 6, 7, oh, it's two.

RC: Take away three.

Partner: ___ and two more is

RC: take away three

Partner: Seven and two were 10.

RC: Three.

Partner: Yeah that's true, it's two, it's two.

RC: five, six, seven

Partner: That is actually two.

RC: I will work it out myself.

Partner: See, it's two.

RC: Partner, I will work it out myself

Extract 6

RC: Mum, you help me a bit, 'cause its real, it's a bit hard.

Adult: ___

RC: You could just help me a little bit, it's just that, that, what does, I just need help, what does those arrows mean, and that word mean?

Adult: Which word?

RC: That word, what does?

Adult: Fewer, oh ok, fewer's like less. Look at this, how many more to make seven, so if you've got seven things?

Partner: What goes in here?

Adult: Hold on a second, Partner, I'll just answer a question for Research Child. So if you've got seven things, how many do I need to make ten?

RC: Those two, two.

Adult: Is that right?

RC: Yep.

Adult: No, look.

RC: Bummer.

Adult: How many more do you need to make ten?

RC: Three.

Adult: Okay, see.

RC: So it's three down here.

Adult: Mmm hmm.

Analysis

Language focus:	Amounts (additions to ten)	Amounts in relationship to more and fewer
Language skills:	Reading, writing, listening and speaking	Reading, listening, speaking
Authority:	Each student but with Partner prevailing	Mother (as perceived by both RC and her partner)
Negotiation of interaction:	The students had to complete a worksheet. Partner tried to work with RC but she was not keen to interact.	RC initiates interaction but the mother changes the focus after seeing an incorrect written answer.
Impact on learning of mathematics register:	With each student not recognising the authority of the other, there was limited interaction. A consequence of this is that it was unlikely that much learning occurred.	Although the RC completed her worksheet, she may not have learnt anything more than that she now had the correct answer ('so it's three down there'). This may have been because the responsibility for directing her own language learning was reduced.

Comparison

The context for both episodes is completing the worksheet on basic addition facts. The RC does not value her partner but rather her mother in providing support to get the 'correct answer'. Her lack of valuing of both of her partner's knowledge but also her own knowledge means that, in these episodes, there is no negotiation of meaning. Mathematical terms make the conversation sound like mathematics but in fact little mathematics is likely to have been learnt and misunderstandings were not recognised.

CONCLUSION AND IMPLICATIONS

This initial investigation of this case study data suggests that how authority about mathematics was perceived by our research child did have impacted on her acquisition of the mathematics register. When she needed to know or do something mathematical, then she contributed more to the interaction. In the home situation, the child seemed to have more opportunities for initiating mathematical interactions. As a consequence, the aspects of the mathematics register that arose may have been more easily acquired because they had immediate relevance for the child. However, when the purpose of the mathematical activity was just to complete a worksheet, it is difficult to know how sustained the learning may have been.

Giving preference to mathematical meaning was not something that was done by the child in these pairs of interactions. Rather this was done by the adult, although in extract 2, the child did try to usurp this preference for the mathematical meaning by gaining control of the rule book that was the default authority in this interaction.

This investigation raises some interesting points about how authority affected the acquisition of the mathematics register. For an activity to support the acquisition of the mathematics register, it would seem that the child should be more actively involved in the learning interactions. This seemed to occur more readily in the home environment. At some point, it may be also that the child needs to recognise her own authority in knowing about mathematics. More work is also needed to identify other ways to acquire the mathematics register so that a student's acquisition of it does not have to result always in ventriloquating that of their teacher or other adult (Forman, McCormick and Donato, 1998).

REFERENCES

- Amit, M. and Fried, M.: 2005, 'Authority and authority relations in mathematics education: A view from an 8th grade classroom', *Educational Studies in Mathematics Education*, 58, 14-168.
- Australian Education Council: 1991, *A national statement on mathematics for Australian schools*, Curriculum Corporation, Melbourne.
- Chronaki, A. and Christiansen, I. M.: 2005, (eds.) *Challenging perspectives on mathematics classroom communication*, Information Age Publishing, Greenwich, CT.
- Forman, E. A., McCormick, D. E. and Donato, R.: 1998, 'Learning what counts as a mathematical explanation', *Linguistics and Education*, 9(4), 313-339.
- Halliday, M. A. K.: 1978, *The social interpretation of language and meaning*, University Park Press, London, pp. 194-204.
- Meaney, T. (2006). Mathematics Register Acquisition, *set 3*, 39-43.
- Moschkovich, J.: 2003, 'What counts as mathematical discourse', in N. A. Pateman, B. J. Dougherty and J. Zillox (eds.), *Proceedings of the 27th Annual Meeting of the Group for the Psychology of mathematics education*, University of Hawaii, Honolulu, vol 3, pp. 325-331.
- New Zealand Ministry of Education: 2006, *The draft New Zealand Curriculum Framework*, Learning Media, Wellington.
- Rogoff, B.: 1990, 'The joint socialisation of development by young children and adults' in V. Lee (ed.), *Children's learning in school*, Hodder & Stoughton, London, pp. 41-58.
- Young-Loveridge, J. M.: 1987, *The Development of Children's Number Concepts*, Education Dept., University of Canterbury, Christchurch.