Reforming Communication in the Classroom: One Teacher's Journey of Change

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This paper describes the phases in a journey one teacher and her students travelled during a year long teaching experiment designed to reform classroom communication norms A study group environment supported the teacher to examine reflectively the discourse patterns enacted in the classroom Data indicated that the communication norms constituted in the classroom significantly influenced the discourse context and student engagement in mathematical practices Student autonomy and collective responsibility increased within the enacted inquiry and argument contexts as the teacher positioned herself as a facilitator

Reform efforts over the past twenty years have set ambitious goals for change in teaching and learning practices in New Zealand mathematics classrooms (Ministry of Education, 1992) Changes advocated include a need for students to learn "to communicate about and through mathematics" (Ministry of Education, 1992, p 11) Current policy documents also note the potential value of outcomes when students "learn by interacting with each other" (Ministry of Education, 2004a, p 9) The important role of communication is also recognised within international policy documents (e g , DfES, 2001; National Council of Teachers of Mathematics, 2000) Statements within these documents affirm the significance of classroom interactions and the nature of the discourse, for the development of the kinds of mathematical thinking and learning envisaged within their policy strategies However, how teachers are to develop and support mathematical discourse communities and the role they are to fulfil within them is seldom clarified within these policy statements Therefore the purpose of this paper is to elaborate on a journey of change that a teacher and her students took over one year, while constituting communication norms which supported the development of a mathematical inquiry-based reform culture The focus of the paper is on the students' communicative phases, and the communicative strategies the teacher used, to support development of mathematical practices

For many teachers, successful implementation of mathematics education reform may require a transformation of long held beliefs and practices This shift involves moving from a view of mathematics learning as individualistic and passive towards that of social endeavour in which students come to know and do mathematics through participating in communicative activity within classroom discourse communities (Wood & McNeal, 2003) In such communities the teacher's role is structured to socialise students into the mathematical discourse community—a community in which authority is jointly shared between teacher and students—and the discipline of mathematics itself (Boaler, 2003) In this role the teacher is positioned as facilitator, orchestrating student action and inducting students into the mathematical practices of successful problem solvers (Goos, 2004) In turn, students engage in discursive communicative interaction of the inquiry based reform practices, proposing and defending their mathematical theories as they participate in activity characterised as mathematical practices In the context of this paper mathematical practices are considered to comprise "such actions as exploring, orienting, representing, generalising, and justifying" (Boaler, 2003, p 8)

In inquiry-based, reform oriented communities there are not singular models of practice (Boaler, 2003) They each have distinctive environments which are distinguished from others by the interactive and communicative exchanges within them and the levels of cognitive demand these entail (Wood & McNeal, 2003) Educators and researchers in the promotion of reform have placed increasing importance on fostering discourse communities which exhibit specific communicative properties The common theme advanced has been the importance of the communicative patterns of mathematical argumentation, challenge and debate, to stimulate deep student engagement in mathematical practices (Boaler, 2003; Brown & Renshaw, 2004; Rojas-Drummond & Mercer, 2003; Wood & McNeal, 2003)

Wood and McNeal (2003) discuss argumentative classroom communities They differentiate these from other discourse cultures of inquiry-based reform communities, by their variation in communication patterns This includes the use of collective argumentation (Brown & Renshaw, 2004) and exploratory talk (Mercer, 2000) According to Wood and McNeal (2003) the communicative expectation of challenge or disagreement from listening members is what extends explanations to justification It is also what distinguishes an argumentative culture from a second culture they classify as inquiry Inquiry cultures are characterised by the expectation that students will communicate reasons for their thinking, and clarify their thinking through further questioning However their explanations are not subjected to challenge and debate The third classification Wood and McNeal (2003) identify, is that of strategy reporting Within this culture, the communicative norms focus on presentation by students of different strategy solutions with communication patterns most often characterised by cumulative or disputational talk (Mercer, 2000) Questioning is used to gain information, but students are not required to provide backing for their thinking Thus cognitive demand and student engagement in mathematical practices is lessened (Mercer, 2000; Wood & McNeal, 2003)

Establishing classroom cultures which encompass argumentative elements of communication is a challenging task, particularly because such practices may bear little resemblance to what many teachers have previously experienced as mathematics learners (Hufferd-Ackles, Fuson & Sherin, 2004; Nathan & Knuth, 2003) This paper maps out how the communication norms constituted by one teacher and her students supported a gradual shift from a strategy reporting context, to an inquiry context, and finally to an argumentative context

The theoretical standpoint of this study is derived from a sociocultural perspective on learning in which "social practices are discursively constituted and that people become part of practices as practices become part of them" (Lerman, 2002, p 88) From this perspective, social and communicative factors are mutually constitutive With respect to practices in the classroom, engaging in mathematical practices is about learning the practices and becoming a member of a mathematical community Within the sociocultural lens, learning to be a member of a classroom community of practice (Lave & Wenger, 1991) is a dynamic process, involving shifts in positioning of all members of the community

Research Design

The study reports one teacher case study from a teaching experiment (Cobb, 2000) involving three teachers The study was conducted at a New Zealand urban primary school whose students came from predominantly low socio-economic home environments Students were predominantly of Pacific Nations and New Zealand Maori ethnic groupings

Within the context of monthly study group meetings a community of learners consisting of the teachers and researcher was developed (Franke & Kazemi, 2001) The year long collaborative partnership between the researcher and teachers supported the development of a series of hypothetical communication trajectories and a framework of mathematical practices The teachers used the trajectories and the framework of mathematical practices to map their progress and focus their next communication goals Data collection over one year included twice weekly video captured observations of complete lessons, detailed field notes, classroom artefacts, written and recorded teacher reflective statements, three teacher interviews, and teacher recorded reflective statements of video excerpts

On-going data analysis supported continual revision of the communication and participation strategies Analysis generated categories and provided theoretical insight into developing communication patterns and student engagement in mathematical practices

Analysis of data took place chronologically using a grounded approach creating codes, categories, patterns and themes The teachers and researcher in collaborative partnership identified critical incidents where members of the classroom community appeared to be negotiating new ways to communicate and engage in mathematical practices Trustworthiness was then verified or refuted in a crisscross procedure of conjecture and refutation, using a constant comparative method

Results and Discussion

Early Changes to the Discourse Context

The teacher in this study had been a participant in the New Zealand Numeracy Project (Ministry of Education, 2004a) two years previously and used Numeracy project lesson outlines in her mathematics teaching (Ministry of Education, 2004b) The teacher had embraced reform to a degree but was ambivalent in her beliefs about the value of communication, and the length of time mathematical discussions took in her mathematics lessons She reflected this in those practices she had appropriated and established in the classroom The students were encouraged to generate a range of strategies and solutions which they then described to a larger group within a context of strategy reporting The focus however rested on turn-taking Opportunities to extend mathematical thinking from explanations were not utilised as this initial observation of a group sharing session at the start of the study demonstrated:

> Sarah: The rule was timsing it by two and it goes up
>
> Teacher: Good Right your group now Rachel How did you get your answer?

During initial observations, cumulative or disputational talk (Mercer, 2000) was a consistent feature of the classroom communication structure In the following excerpt, the students in a small problem solving group have constructed an explanation cumulatively through agreement Debate or expectations to provide reasons for answers were not present:

> Aroha: If you have sixty four animals to go in four paddocks I would put 10 animals in each paddock
>
> Jane: Then put five into each paddock…
>
> Aroha: Equals sixty and then four left so one in each paddock and then there were sixteen in each paddock

Hinemoa then provided a counter-claim as an alternative explanation, and Jane immediately agreed:

> Hinemoa: If you go sixty four divided by four it would equal sixteen
>
> Jane: Yeah I agree

Aroha asked for further clarification In response Jane resorted to disputational talk:

> Aroha: But how did you know that?
>
> Jane: Because she's brainy

Jane's use of disputational talk meant that Hinemoa did not have to provide backing for her thinking nor clarify her reasoning

Changing the Discourse Context

Reforming classroom cultures is challenging and complex The use of a series of communication trajectories, set within a framework of mathematical practices (which included teacher and student prompts) was an important reflective tool for change

> Teacher: You know when we first started talking about these things called mathematical practices I don't think anyone of us really understood what they were and we were just going like yeah, yeah yeah But for me looking at the video clips of my classroom one day I heard myself ask some question like why or how and then the kids were really getting into the maths I think all three of us…and other teachers have taken them too have used the framework and I don't really use it all the time now but it does keep me thinking about how the kids are talking and that's how I have got them justifying [concluding interview]

The use of the framework and hypothetical communication trajectory precipitated the teacher to shift the discourse norms:

> Teacher: My intention is now to up the ante a little, time to move out of that nice cosy place we are in I want the students to engage in meaty discussions, question why, even some arguing if they disagree with someone [interview after the first month of the study]

In stating the intention to shift the norms, the teacher indicated a sense of confidence in the readiness of the community to encounter challenge and uncertainty within an inquiry or argumentative culture

In order to enact a learning culture, within which mathematical learning could be conceptualised as increased communication in a discourse community, the teacher used explicit strategies She gave direct attention to the development of specific patterns of discourse, as the students were coached in ways to question each other, in order to deepen their reasoning:

> Teacher: If you don't understand, what questions do you need to ask?
>
> Sandra: I don't understand, could you please repeat it?
>
> Teacher: If someone didn't understand it though and the same thing was said to them…

The teacher has challenged Sandra to consider the validity of repeating an explanation and placed responsibility back with Sandra to consider alternative questions:

> Sandra: Oh explain it in a different way, an easier way, or a clearer way… or like how did you work that out… can you show me how you did it and what you used

Problem solving groups were used to develop group explanations and students were guided to practise questioning sections, in order to make sense of each others' explanations:

> Teacher: I want you to explain to the people in your group how you think you are going to go about working it out Then I want you to ask if they understand what you are on about and let them ask

you questions Remember in the end you all need to be able to explain how your group did it so think of questions you might be asked and try them out

Within this second phase, collaborative interaction and active listening were positively affirmed The teacher offered students direction in ways they could structure their thinking, so that they could engage in mathematical inquiry during large group sessions:

Teacher: Okay so I have heard lots of talking, discussing in your groups and listening to each other and that's good Now this group is going to explain and you are going to look at what they do and how they came up with the rule for their pattern right? Then as they go along if you are not sure please ask them questions Tune in here, step by step, and as they go along if you can't make sense of each step remember ask those questions

Questioning was also used by the teacher to re-position her role as facilitator Students were increasingly expected to ask clarifying questions and the teacher actively provided pause and wait-time during sections of explanations In doing so, the teacher provided the students with space in which to "meaningfully explore their own ideas, articulate them, and to explore the thinking of others" (Nathan & Knuth, 2003, p 177)

Teacher: Pen down Have a look and think Now has anyone got a question they want to ask of Rewa at this point?

Sioni: Why isn't that three?

Teacher: Why isn't what three?

The teacher's revoicing of the question caused reshaping of what is being asked At the same time responsibility is positioned with Sioni to clarify exactly what he is asking:

Sioni: Why don't you plus three and not two there when you are adding triangles on?

A pause was then provided by the teacher She then affirmed the elaborated question and acknowledged that it was not only Rewa who had to answer—but a collective responsibility of the group:

Teacher: Yeah that's a good question because when you think of triangles you do think of three not two…Rewa can you answer that or do you want someone else in your group to?

The teacher recognised that for the students to access the discourse of argument contexts they needed to be able to disagree and challenge However, she also indicated in an interview midway through the study, that this was a practice with which students needed time to become more confident and comfortable:

Teacher: Disagreeing is so hard for these children so I am supporting them and ensuring that they're okay with the concept of agreement and disagreement also how to approach each other when voicing their opinions

Further support of discourse as exemplified in argumentative classes involved explicit discussion about what arguing mathematically meant The teacher explored the strategies the students could use when doing so:

Teacher: Arguing is not a bad word…sometimes I know you people think to argue is…I am talking about arguing in a good way So please feel free if you do not agree with what someone has said as long as you say it in an okay way A suggestion could be that you might say I don't actually agree with you, could you show that to me Do you think you could prove it mathematically, could you perhaps write it, or draw something to show that idea to me…and sometimes doing that the other person thinks it wasn't quite right so they change their idea and that's okay

The teacher's facilitation of students into collaborative forms of reasoning resulted in gradual growth of student autonomy and concomitant changes in the discourse culture

Boaler's (2003) metaphoric 'dance of agency' (p 3) was enacted as increased student responsibility for both individual and collective reasoning was facilitated and the discourse shifted to that of exploratory talk (Mercer, 2000) Mid-way through the year it was evident that authority in the mathematical classroom had shifted No longer was the teacher the sole authority: it was now shared between the teacher, the students, and the discipline of mathematics

Owning the Change in the Discourse Context

During the final section of the study, the gradual shift in authority the teacher had enacted, repositioned her as the active facilitator of discourse Sense-making and mathematical justification of ideas and arguments were achieved within collaborative zones of proximal development Participating in discursive interaction enabled collective thinking and made the students more aware of their reciprocal rights and responsibilities Increasingly, the students became aware of their responsibility to the community to ensure the reasoning behind their explanations made sense for all listeners This is illustrated in the following excerpt when Rose has noticed a puzzled look on the face of a member of the large listening group Without appeal to the teacher she has assumed responsibility for exploring reasons for the puzzlement

> Rose: Casey you look puzzled?
>
> Casey: I am puzzled…well three squares times three sticks, it doesn't make sense to me
>
> Teacher: Well perhaps…

Huia (another member of the explaining group) has halted the teacher comment and then she has assumed collective responsibility to clarify a section of the explanation:

> Huia: It is okay I can answer that After the first square she went like adding on three each time to get three squares

Embodied in argumentative classes where collective argumentation and exploratory talk occurs, is the notion of challenge and disagreement Within argumentative classes, communicative strategies involve negotiation, sense making, contribution to arguments, provision of different perspectives, and reasoning and justification (Mercer, 2000) The following excerpt shows this when a student was challenged after making an explanation using an illustration:

> Debra: Why did you shade in two tenths and call it one fifth? You didn't explain why you just said there was only one fifth left and you just shaded it in?

In response Aroha, a second member of the sharing group, assumed authority to provide backing for the explanation, and used both the illustration and the discipline of mathematics itself, to justify the explanation:

> Aroha: I can explain why…an easier way because when you divide tenths into fifths there is two of the tenths resembles one of the fifths so that's why she shaded in two because it equals one of the fifths because…two tenths is equivalent to one fifth

Throughout the final section of the study the teacher explicitly used discourse to scaffold student dialogue which evoked discursive interaction, and deepened student engagement in mathematical practices:

> Teacher: When someone in the group is explaining they have taken the problem and they are trying to convince you You need to be asking questions What are you doing? What did you write that

for? Why did you write that? Will that way work all the time? You need to expect different ways too, pictures but also for them to prove it using numbers

Within the discursive interaction of challenge and debate, student autonomy, reflective analysis, and a range of mathematical practices emerged, as is illustrated in the following excerpt One group has explained their thinking while other members of the listening group have actively listened to the explanation The teacher withholding her evaluative authority has caused the listening students to challenge the reasoning of the explainer:

Teacher: Now are you convinced with that explanation? Jump in if you have a question

Hoani: Two fifths can't be the same as one half?

Cherie: He ate two fifths of what he took not two fifths of the cake So out of the cake he has eaten…well there's two ways to do it…he's eating two tenths which is also equivalent to one fifth (records using symbols)

Cherie (a second member of the explaining group) has assumed responsibility to respond to the challenge to justify and provide alternative proof She then provided reflective analysis of the misconception in a previous group's explanation:

Cherie: …and because this is the reason why I think these guys went wrong Denny took two fifths of a cake the same size as Ruru's…of a cake…doesn't mean the same cake so I will show you (draws a rectangle which she divides into five sections) so I have divided the cake into fifths and he took two fifths so I am going to shade in two fifths but he could only eat one half which is one fifth of what he took

Teremoana continued the debate, demonstrating confidence to challenge until convinced:

Teremoana: Yeah but Ruru took a half so he took more?

Cherie: I think they ate the same amount because Ruru only ate two fifths of the half so look…

The challenge and debate had created multiple zones of proximal development Joseph has tracked the discussion closely At this point in the discussion, he has taken the recording sheet and pointed at the representations recorded by previous explainers, then re-recorded the symbols as he justified and provided proof for the previous explanation:

Joseph: No, no, no, I have got an explanation See it is like multiplication It is because each one is using the same fraction and they have just turned around (he records the symbols for two fifth multiplied by one half and then reverses them)

Furthermore his use of mathematical symbols and explanation had provided generalisation of a mathematical pattern

Conclusions

The teaching experiment involving a series of communication trajectories was designed to build communication and participation patterns which supported the development of inquiry and argument discourse contexts Wood and McNeal (2003) have identified differences in norms between the contexts of strategy reporting communities and inquiry and argument communities These differences were evidenced in this study In addition the findings of this study suggest that the established norms for a strategy reporting community served as a foundation for developing the norms of an inquiry community, and in turn an argument community

The findings of this study elaborated how increasingly sophisticated discourse was constructed by the classroom community, in response to changes in the classroom communication norms In this way, the initial use of cumulative discourse as the dominant

feature of the strategy reporting community, evolved through teacher scaffolding The students shifted through the inquiry community model to an argumentative community in which discursive interaction supported exploratory (Mercer, 2000) and collective argumentation (Brown & Renshaw, 2003) These findings are consistent with Mercer's (2000) argument that learning communities reshape their discourse patterns in response to communicative demands

Overall the enactment of a mathematical discourse culture based on inquiry and argument, increased student autonomy and deepened the collective responsibility of the students to engage in mathematical practices

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