## Engaging Students in a Variety of Classroom Talk Formats that Afford Knowing and Doing in School Mathematics

| Raymond A. J. Brown | Elizabeth W. Hirst |
| :---: | :---: |
| Centre for Applied Language and | Centre for Applied Language and |
| Communication Studies, Griffith | Communication Studies, Griffith |
| University. | University. |
| [ray.brown@griffith.edu.au](mailto:ray.brown@griffith.edu.au) | [e.hirst@griffith.edu.au](mailto:e.hirst@griffith.edu.au) |


#### Abstract

Classroom talk is regarded as essential in engaging and developing student understandings in the domain of mathematics. The process of classroom talk, however, may occur in quite different ways. In this paper we analyse two forms of classroom talk - replacement and interweaving. These provide a heuristic for considering how teachers might develop a repertoire of practices that they may deploy to afford student learning. In an analysis of student talk in a Year 7 classroom we found that replacement and interweaving can facilitate learning. We conclude that teachers should use classroom talk formats reflectively and intentionally in their classrooms to afford students a range of opportunities to develop their mathematical thinking.


## Introduction

The history of coming to know and do mathematics in the school classroom has focused on teacher activity through the employment of transmission, discovery, and constructivist approaches to teaching and learning. Recent emphasis has centred on the mediating role that language plays in assisting students to participate in the sociocultural practices of mathematics (see Lampert, 1998; Cobb, P., McClain, K., \& Whitenack, J., 1997). The sociocultural practices of mathematics encompass the privileged ways of knowing and doing that characterise mature communities of mathematicians, for example, inquiry approaches to knowing and doing. Wertsch and Rupert (1993), sociocultural theorists, promote a view of human action that complements this emphasis.

Wertsch and Rupert (1993) advocate a view of teaching and learning that positions individual functioning within systems of collective practices that are culturally and historically situated. This approach, which they label 'mediated agency', describes the "irreducible tension" manifested between agent/s on the one hand and the mediational means (language, signs, symbols, etc.) that they employ or have access to on the other (Wertsch \& Rupert, 1993, p. 230). From this point of view, issues that effect the sociocultural organisation of mental functioning on the social plane, such as issues related to power and authority, are seen as essential aspects of functioning on the personal plane. A key theoretical claim of 'mediated agency' is that human action, including social and personal functioning, is fundamentally shaped and constrained by mediational means such as the ways the teacher and students talk to each other when engaged in teaching and learning. In this paper we consider the mediating role played by different formats of classroom talk on students' participation in the sociocultural practices mathematics.

Recent analyses of classroom talk (see Renshaw \& Brown, 2000) have provided insights into the variety of discourse formats deployed in classrooms as teachers attempt to integrate students' ways of knowing and doing with the more formal, abstract ways of knowing and doing valued by knowledge communities. Renshaw and Brown (2000) identified that the integration of the everyday with these more abstract or 'scientific' ways may be mediated by four different formats of classroom talk (forms of collective action that are socially and historically situated) - replacement, interweaving, contextual privileging, and pastiche.

In the replacement format of classroom talk, progress in understanding is measured by the extent to which mathematical representations replace the more concrete and everyday ways of representing knowledge. Initially, there is attention and space given to the perspectives, words and values that students bring with them into the classroom talk, but these provide a temporary bridge into new forms of speaking and thinking. The pedagogical process in the replacement format requires students to work within a system of signs and symbols with its own logic and set of meanings, rather than to oscillate between everyday (e.g., pictorial) representations and mathematical abstractions. Within this pedagogical process it is the voice of the teacher that dominates. The teacher is the expert, and it is the teacher who focuses on mathematical practices such as 'representing' and 'comparing' and on mathematical goals/values such as 'efficiency' and 'clarity'. These formats are characterised by IRE (initiation, response, evaluation) patterns of classroom talk (Mehan, 1979). Knowledge is represented as fixed and the role of the teacher is to replace students’ everyday concepts with 'scientific' concepts.

Interweaving refers to a type of classroom talk where students can populate mathematical discourse with their own purposes, for example, those relating to personal challenge, perseverance and discovery. Students weave together their mathematical ideas with the ideas of others into a form of discourse that reflects their specific circumstances. Interweaving can occur at a number of levels. For example, it may occur at a level where students' inventive ideas may be interwoven with the conventions of mathematics through employing salient elements of a conventional approach to scientific inquiry (e.g., hypothesising, testing, validating). It may also occur at a more personal level where students' individual approaches to doing mathematics are interwoven with the more flexible representation systems employed by more expert mathematicians, for example, the teacher or other students. The interweaving of different perspectives in the classroom talk appears productive in enabling students to appreciate the relevance of 'mathematics' in coming to 'know' and 'do' school mathematics tasks - in the construction of a local hybrid form of knowing (see Ballenger, 1997).

While similar to the replacement format in marginalising certain types of discourse, the contextual privileging format differs from the replacement format in highlighting the situational and context-specific grounds for privileging one type of discourse over another. It's not that some mathematical representations are qualitatively better in some general sense, but rather that students are urged to adopt certain ways of speaking because they are appropriate to the particular setting with its assumed ground rules for participation. The important aspect of the interaction between the participants is not just the use of symbolic representations, but the use of context-based arguments
appropriate to the mathematical context of classroom discourse. This is a sophisticated format that entails judging the worth of an idea based on its relevance to a particular setting.

The pastiche format of classroom discourse highlights multiple representations of concepts and the multivocality (Wertsch, 1991) of students' talk, that is, the social ways of communicating that characterize various group behaviours (e.g., peer, socioeconomic, political, professional, etc.). The pedagogy is not primarily focused on replacing one representation of an idea with another, but on eliciting and communicating diverse ways of thinking about and talking about concepts. Participation in a pastiche format of discourse is marked by students placing multiple representations of a concept out in the open for consideration by others. Each representation is offered from a specific speaking position that may be drawn from various discourse communities, thus in the exploration of a concept there is neither interweaving nor replacement, but an acceptance of diverse alternative voices depending on the chosen stance/s of the speaker (for example, that of a classmate, philosopher, scientist, mathematician, etc.).

It is our belief that effective classroom teachers employ a variety of communicative formats in any single learning session so as to maximise student access to the affordances of that situation and to minimise constraints on personal understanding. In order to investigate this belief we examined a classroom mathematics lesson.

## The context of the lesson

The lesson was conducted in a Year 7 classroom in an inner city primary school. The participants in the lesson were the teacher (an author of this paper) and 22 students (10male; 12 female). The lesson occurred within the planned time frame and sequence of this classroom's way of engaging the Year 7 Queensland Mathematics syllabus. It employed a pedagogy that the teacher and students considered to be a normal part of their school day - Collective Argumentation (see Brown \& Renshaw, 2000). Collective Argumentation is a collaborative problem solving approach to teaching and learning that is organised around a key word format - represent the task or problem alone, compare representations within a small group of peers, explain and justify the various representations to each other in the small group, reach agreement within the group, and finally present the group's ideas and representations to the class to test their acceptance by the wider community of peers and the teacher.

## The content of the lesson

Lesson content revolved around the concept of percentage. In previous lessons the students had revised the concept of percentage and students had been engaged in translating various percentage amounts into their decimal and common fraction equivalents. This lesson situated these understandings within a familiar context representing, in terms of percentage, the number of green, red, blue, and brown M\&Ms (lollies) within a packet that contained 40 green, 20 red, 16 blue, and 4 brown M\&Ms. Each student had been provided with a drawing of a hundreds grid with a blank circle in each of 80 cells.

## Data collection and utilisation

The lesson was video-taped and transcribed for analysis. For the purpose of analysis, that is, to investigate the formats of classroom talk deployed in order to afford individual students access to ways of knowing and doing mathematics, only those sections of the lesson where the teacher was engaged with individual students on a one-
to-one basis were examined. Due to the constraints of this paper, only data relating to the 'replacement' and 'interweaving' formats will be addressed.

## Analysis and Discussion

## Replacement - The teacher working with Brian.

Brian is a student with a history of severe learning difficulties. Identified as a student at risk, Brian has been undertaking 'Individual Education Programs' since his second year of formal schooling and has been regularly withdrawn from classes throughout his primary school years to participate in learning sessions conducted by the Learning Support Teacher. This year, Brian's parents have negotiated with the classroom teacher to have him included in the mainstream activities of the class.

Brian chose to attempt the M\&M problem. Using coloured pencils he had inserted green, red, blue, and brown strokes in circles in the 100s grid that was provided to him and had recorded the following beside the grid: $40 / 80,20 / 80,16 / 80,4 / 80$. We enter the script where the teacher has come along to check on Brian's progress.

| Turn No. - Speaker | Script |
| :--- | :--- |
| 01 -Teacher: | What have you got here (points to the fractions beside the hundreds <br> grid)? |
| 02 - Brian | I just wrote down, like (refers to problem text) there are eighty M\&Ms in <br> the box so I put (points to 40/80) forty over eighty ... um . |
| 03 - Teacher | That's excellent. So how may (M\&Ms) out of the eighty (refers to the <br> problem text) are green? |
| 04 - Brian | (No response.) |
| 05 - Teacher | Forty out of eighty (points to 40/80 that Toby has represented). So that <br> as a fraction... Is there a fraction that you know that you can relate to <br> forty out of eighty? |
| 06 - Brian | Nope |
| 07 - Teacher | What if it was four out of eight? |
| 08 - Brian | No. |
| 09 - Teacher | If you had four out of eight what part of the box (of M\&Ms) would you <br> have? |
| $10-$ Brian | (Begins to tap his fist of the desk in a nervous fashion.) Four percent of <br> it? |

In an effort to clarify Brian's representations of the common fractions he recorded, the teacher's questions demonstrate that Brian is not relating his symbolic representations to the concept of a fraction. That is, he does not view the symbol 40/80 as relating a part (the number of green M\&Ms) to the whole ( 1 packet of M\&Ms). Although he is able to say that there are 40 green M\&Ms out of 80 (Turn 3), in much the same way that he is able to say that a person scored 40 marks in a test out of 80 , it seems he is unable to relate this to a fractional understanding such as a half. Brian's representation of 40/80 bears a strong relationship to his pictorial representation, but little or no relationship to a conceptual/symbolic understanding of fraction. In the following, the teacher endeavours to replace Brian's pictorial representations with a symbolic representation (1/2).

| Turn No. -Speaker | Script |
| :--- | :--- |
| $11-$ Teacher | All right. What if it was one out of two? |
| $12-$ Brian | Four ... |
| $13-$ Teacher | What is it when you say we have one out of every two? |
| $14-$ Teacher | (Takes a box of lollies and empties them onto the desk.) |
| $15-$ Teacher | (Referring to the lollies on the desk.) How many are there? |
| $16-$ Brian | (Counts by ones pointing to each lolly as he counts.) Six. |


| 17 - Teacher | Can you give me half? |
| :--- | :--- |
| 18 - Brian | (Takes 3 lollies to his side of the desk.) |
| $19-$ Teacher | (Takes 3 lollies to his side of the desk.) That half is mine. |
| $20-$ Brian | Yes. |
| 21 - Teacher | So it could be half ... could be one out of every two is mine. <br> (Teacher lines up the halves so that they are in one-to-one <br> correspondence.) |
| 22 - Teacher | (Referring to each pair of lollies in the line.) Out of those two, that one is <br> mine. (Performs the action of bringing two lollies together and taking <br> away one.) Out of those two, that one is mine (repeats the action). Out <br> of those two that one is mine. (Repeats action.) So that's (the group of <br> lollies on his side of the desk) a half, isn't it? |
| 23 - Brian | Ah Hum. |

In this section of the script, the teacher revises with Brian the concept of a half through the action of manipulating concrete objects (lollies). Brian's action in Turn 18 suggests that he understands the concept of a half in this context (sharing equally a small number of concrete objects). The teacher then attempts to relate this knowledge to the problem task by using like symbols ( 4 relates to 40 and 8 relates to 80 ) as illustrated in the following text.

| Turn No. -Speaker | Script |
| :--- | :--- |
| $24-$ Teacher | So here, (points to Brian's 40/80)... What if I had eight? (Takes Iollies <br> from the packet, finds that he is one short and substitutes a small eraser <br> in its place, then gathers all the objects together.) Eight! So there are, <br> we have eight. Could you give me half? |
| 25 - Brian | (Brian takes away four lollies to his side of the desk.) |
| $26-$ Teacher | I notice that I got the 'dodgy' one (the eraser), thanks. |
| $27-$ Teacher | Okay, so that's four out of eight... is a half. So here (pointing back to <br> the problem text), if I've got four out of eight of the M\&Ms... |
| 28 - Brian | Fifty percent. |

Building on Brian's knowledge and now reintroducing the original problem, the teacher asks Brian what fraction four M\&Ms out of eight M\&Ms relates to, but before he can finish, Brian responds with 'Fifty percent’ (Turn 28). In most classrooms, this response would be applauded by the teacher and the student encouraged to generalise this response to 40 out of $80 \mathrm{M} \& \mathrm{Ms}$. After all, the learning session was focusing on 'percentage'. However, as can be seen in the following script the teacher does not accept this response.

| Turn No. - Speaker | Script |
| :--- | :--- |
| 29 - Teacher | Is it a percent? Isn't percent related to a hundred? We are just talking <br> about language that we should be familiar with, like one half or a whole <br> or a quarter. So if I have ...four out of eight is a half. So, if you've got <br> (points back to Brian's 40/80) forty out of eighty, can you tell me what <br> fraction of the whole you've got there? |
| 30 - Brian | Um ... a half. |
| 31 - Teacher | A half. So, (pointing back to the problem text) half of the M\&Ms are <br> green. And you've coloured those in (points to Brian's hundreds grid). <br> Now it's hard to see those being a half (the green circles in the grid), the <br> way its represented there, but half of the M\&Ms in that box are ... green. <br> We can also express a half as being four over eight or (points to 40/80) <br> forty eightieths. |

The teacher's refusal to validate Brian's response at this stage of the learning process is not surprising if one considers the aim of the teacher as expressed through this episode of classroom talk. The teacher is attempting to replace Brian's concrete representations of the problem task with symbolic representations that relate to a conceptual understanding of a half - a conceptual understanding that the teacher considers to be a 'benchmark' in a student's mathematical development (see Turn 29). Brian's response "fifty percent" relates indirectly to the concept of a half in that it may be represented as fifty out of a hundred or 50/100. In turn, the symbol 50/100 relates to the concept of a half by means of the relationship of the numerator (50) to the denominator (100) - fifty parts out of a hundred, one out of every two parts. As such, expressing four out of eight or forty out of eighty as 'fifty percent' has the potential to provide an explanatory object which Brian and the teacher may use to recognise, form, and distinguish the concept of one half, but, according to the teacher, it is not as powerful as the explanatory object that is provided when four out of eight or forty out of eighty is expressed as a common fraction $4 / 8$ or $40 / 80$ or $1 / 2$. In the teacher's words, "... half of the M\&Ms in that box are ... green. We can also express a half as being four over eight or (points to 40/80) forty eightieths." (Turn 31)

Having established that Brian has the necessary explanatory objects in front of him to make the connection between $40 / 80$ and $1 / 2$ and the green M\&Ms in the packet ([a]the concrete representation: four out of the eight lollies; [b] the pictorial representation: the coloured pencil strokes representing the green M\&Ms; and [c] the symbolic representations: $4 / 8$ and $40 / 80$ ), the teacher focuses on percentage.

| Turn No. - Speaker | Script |
| :--- | :--- |
| $32-$ Teacher | Can you express a half as a percentage? If I've got a half of something, <br> what percent have I got? |
| $33-$ Brian | (No response.) |
| $34-$ Teacher | See (placing the lollies back in the box), what's half of a hundred? |
| $35-$ Brian | Fifty. |
| $36-$ Teacher | So, I would have how many percent? |
| $37-$ Brian | Fifty. |
| $38-$ Teacher | Fifty percent. So these greens (points to the hundreds grid and the <br> green coloured circles) are fifty percent of the box. Fifty percent of the <br> M\&Ms in that box of M\&Ms are... |
| 39 - Brian | Green. |
| $40-$ Teacher | Would you like to think with those (the different ways of representing the <br> M\&Ms in the box) for a while ... |

Here it is a general notion of percentage that is being addressed by the teacher (Turn 32). Once again it appears that the teacher is visiting a benchmark understanding that he considers Brian should have appropriated in previous mathematics classes ("If I've got a half of something, what percent have I got?"). Brian's lack of response may be due to the rejection of his previous offer of "fifty percent" (Turn 28). In his prompts the teacher elicits the responses "fifty" (Turn 35) which he reshapes as "fifty percent" (Turns 36-37). The teacher revisits Brian's hundreds grid - no longer as a representation of Brian's thinking, but as a tool that can help students 'see’ that percent means per one hundred or out of one hundred. In this way, the teacher attempts to replace Brian's pictorial representations with sophisticated tools to think about and do mathematics (see Turn 40).

Although this teacher has attempted to 'replace' the student's way of thinking, the kind of learning that is evident is debateable. What is evident is that Brian is learning the role of a compliant student. He has obligingly completed the role he was allocated by the teacher. An analysis of the talk reveals a robust I-R-E pattern that gave Brian little opportunity to do other than 'fill in the gaps'. There was no opportunity for negotiation or alternative constructions. The teacher's script dominates and Brian's script remains marginalised. If we examine Brian's responses in Turn 12 (four ...), it could be argued that Brian had been refining his response from the 'fifty percent' (Turn 28) he had earlier offered. Nevertheless, the teacher's use of this replacement format scaffolded a sequential way of addressing the task that not only modelled a successful solution path, but also permitted the student to experience success and to participate in the solution process at a level that he was familiar with.

Although we acknowledge the efficacy of the 'replacement' format we would caution against its exclusive use and encourage its deployment within a set of practices that are selected intentionally for specific epistemological purposes. It is not uncommon for students who are ascertained with learning problems to be taught almost exclusively in these very teacher directed, teacher controlled ways, that is, in replacement formats. However, the exclusive use of this format may further compound learning problems as it works to marginalise the diversity that these students bring to the classroom and constrains their access to the multiple ways of knowing available to them.

Brian did have several responses that could have been taken up and interwoven. However, the teacher, focussed on the knowledge that Brian 'should' develop, and seeking perhaps also to control Brian's behaviour, provided almost a worksheet type exercise for Brian to participate in. It can be said that the teacher provided to Brian a 'fill in the gaps' exercise that did not afford the opportunity to either interweave Brian's experiences or to interanimate the representations that Brian deployed, but rather, sought to ensure that Brian had the 'right' knowledge.

The 'replacement' format is a traditional way of working with students to replace their more concrete ways of thinking about and doing with sophisticated tools that facilitate understanding and communication and exemplifies one way of participating in the classroom. The principle of 'mediated agency' allows for the use of such formats when the situation requires it, as in the above situation where the teacher, perhaps, was attempting to provide Brian with an understanding of 'fifty percent' that he could share with his group. However, the use of 'replacement' in classroom talk as a default format could hinder the development by students of meaningful ways of participating in mathematics that could assist them to integrate their experiences with the content and culture of mathematics. Another classroom discourse format that emphasises this aspect of learning is 'interweaving' - a format that concerns itself with integrating students' idiosyncratic ideas and representations with the conventions of mathematics.

## Interweaving: Bernice's explanation with the teacher.

Bernice is a student who enjoys participating in mathematics lessons and who usually turns in an above average performance when doing mathematics tasks. In response to the M\&M task, Bernice has represented the following (see Figure 1).

| Bernice's Representation |  |  |
| :--- | :--- | :--- |
| $80 \mathrm{MMs}=100 \%$ |  |  |
| $80 \div 100=1 \%=$ |  |  |
| $40=$ | Green $=$ | $32 \%$ |
| $20=$ | Red $=$ | $16 \%$ |
| $16=$ | Blue $=$ | $12.8 \%$ |
| $14=$ | Brown $=$ | $11.2 \%$ |
| Total $=$ | $72 \%$ |  |

Figure 1: Bernice's representation of the M\&M task.
The above representation shows that Bernice understands the idea that 80M\&Ms equals 100 percent of the packet of M\&Ms. It shows that Bernice is able to use this idea to work out that one percent of the packet equals eight-tenths of an M\&M. However, how Bernice uses this idea to help complete the task is not readily apparent.
We enter the script where the teacher has requested an explanation from Bernice.

| Turn No. - Speaker | Script |
| :--- | :--- |
| 01 - Teacher | Which problem did you do? |
| 02 - Bernice | (Pointing to problem text.) Number one. |
| 03 - Teacher | (Looking at Bernice's representation.) Number one. |
| 04 - Bernice | And I got (referring to representation) 80 M\&Ms equals one hundred <br> percent. |
| 05 - Teacher | So the whole box of M\&Ms (points to the problem text) is a hundred <br> percent? |
| 06 - Bernice | Yes. |
| 07 - Teacher | Okay. |
| 08 - Bernice | And the, I ... eighty divided by a hundred is one percent, which is zero <br> point eight (points to 80 $\div 100=1 \%=0.8$ in representation). |
| 09 - Teacher | Why do you want to find one percent? |
| $10-$ Bernice | So that when you times it (one percent) by a hundred you get a hundred <br> percent. |
| 11 - Teacher | (Plane travels overhead.) |
| 12 - Bernice | I didn't hear that, can you explain it again? |
| 13 - Teacher | Say if you got one percent ... |
| 14 - Bernice | Yeah.(Bernice records as she speaks:1\% x $40=32 \%)$ <br> And you times it (0.8) by 40 green, that gives you thirty-two percent. <br> That would be the percentage of how many green there are ... M\&Ms. <br> And you do the same for the brown and red and blue. But it's worked <br> out wrong, because overall, it came to seventy-two percent, not a <br> hundred. |

In the above text, Bernice uses the sign and symbol system of mathematics to work out that one percent of the M\&Ms is 0.8 , but, probably because she fails to label the 0.8 as part of an M\&M, she is unable to see the connection between $100 \%$ equalling 80 M\&Ms and one percent equalling 0.8 of an M\&M. As a result, Bernice proceeds to multiply 0.8 by the various coloured M\&Ms and to record a percentage for each - a procedure that results in a total of $72 \%$ that Bernice recognises as being "wrong" (Turn 14). At this stage of the interaction, the teacher is simply trying to understand Bernice's way of thinking about and doing the problem as is evident in the following text.

| Turn No. - Speaker | Script |
| :--- | :--- |
| 15 - Teacher | Oh! So it's only added up to seventy-two. So you're saying that one <br> M\&M (takes the biro from Bernice and records the following whilst <br> speaking: 1\% = 0.8 MM)... One M\&M is only point eight of a ... One <br> percent, sorry, one percent... One percent is only point eight of an <br> M\&M, not even a whole M\&M, that's a bit strange isn't it? |
| 16 - Bernice | Yes. |
| 17 - Teacher | So one percent of the contents of this box (points to problem text) is <br> only worth point eight of an M\&M. So now what did you want to find? |
| 18 - Bernice | I thought that if you timesed zero point eight by forty green M\&Ms, that <br> would ... (Teacher records: 40\% = ). |
| 19 - Teacher | That would only give you seventy percent wouldn't it? (Referring to <br> Bernice's representation of 72). |
| 20 - Bernice | It gives you thirty-two percent (referring to 1\% x 40 = 32\%). <br> 21 - Teacher <br> 22 - BerniceBut I don't have forty point eights (of an M\&M), I have forty whole M\&Ms <br> don't I? (Crosses out his record of 40\% = ). |
|  | Yes. |

In coming to understand Bernice's representation ( $1 \%=0.8$ ), the teacher makes the important move of naming and labelling 0.8 as part of an M\&M. Naming classifies and causes participants to view the named object in particular ways, with the chosen symbol emphasising some and ignoring other characteristics of the named thing (Pimm, 1987). However, the notion that one percent can represent anything other than a whole M\&M is a notion that students in this class would find "a bit strange" (Turn 15) as they have only previously related percents to whole units. Upon establishing that "...one percent of the contents of this box is only worth point eight of an M\&M" (Turn 17), the teacher invites Bernice to continue the explanation. After some initial confusion relating to the results of one of Bernice's operations, the teacher, working with Bernice's ideas, draws attention to an anomaly in her reasoning. He now interweaves his voice into the construction of a mathematical relationship, "But I don't have forty point eights (of an M\&M), I have forty whole M\&Ms don't I?" (Turn 21).

| Turn No. - Speaker | Script |
| :--- | :--- |
| $23-$ Teacher | So if one percent is zero point eight of an M\&M (Refers to record: $1 \%=$ <br> $0.8)$, how would you find out what fifty percent was? <br> (Records 50\% = ). |
| 24 - Bernice | It's forty. |
| $25-$ Teacher | I know, but how would I do it sum wise? I know that it's forty because <br> it's half of eighty, but how would I do it sum wise? |
| 26 - Bernice | I don't know. |

Unlike Brian, Bernice understands, and is able to relate to the problem text, benchmark understandings relating to fifty percent and to a half. However, it is not conceptual knowledge that Bernice lacks, but an understanding of how to "find out what fifty percent was" (Turn 26) - a lack of understanding that is approached conceptually rather than procedurally by the teacher.

| Turn No. - Speaker | Script |
| :--- | :--- |
| $27-$ Teacher | Okay, well if one percent is that (points to 0.8), what would two percent <br> be? |
| $28-$ Bernice | One point six. |
| $29-$ Teacher | Twice that (points to 0.8), yes, one point six. What would three percent <br> be? |
| $30-$ Bernice | Two point eight (sic). |
| $31-$ Teacher | Three times that (points to 0.8), two point four. What would ten percent |


|  | be? |
| :--- | :--- |
| 32 - Bernice | Eight. |
| $33-$ Teacher | Eight M\&Ms. So ten percent is worth eight M\&Ms. (Records: $10 \%=8$ <br> mm) So what's fifty percent worth? |
| 34 - Bernice | Forty. |
| $35-$ Teacher | Forty M\&Ms. (Records: $50 \%=40 \mathrm{~mm}$ ) So how can 40 (M\&Ms) be worth <br> thirty-two percent? |
| $36-$ Bernice | I don't know. |

The teacher could have recorded what 2 percent, 3 percent, 10 percent, and 50 percent of the packet of M\&Ms would be using the signs and operations of mathematics. However, he chose to integrate a conventional procedure of mathematics (multiplication) with Bernice's way of thinking. The teacher is not wanting to replace Bernice's way of doing the problem (i.e., find one percent and use this to work out the different percentages for each colour M\&M) with a more efficient way of doing the problem (e.g., convert each colour M\&M to a fraction of the whole and multiply by 100), but to interweave Bernice's way within the conventional understandings of mathematics. In the process Bernice is able to reflect on what she has done and to use conceptual tools to efficiently pursue a successful solution to the task.

| Turn No. - Speaker | Script |
| :--- | :--- |
| 37 - Teacher | See, what you've done is, you've taken point eight and multiplied it by <br> forty (refers to Bernice's representation: $40=32 \%)$. |
| 38 - Bernice | (Inspects her representation.) |
| $39-$ Teacher | You've multiplied M\&Ms by M\&Ms (points to $1 \%=0.8 ; 40=32 \%$, in <br> Bernice's representation of the problem space). I wanted to say, well, <br> that one percent is only worth point eight of an M\&M. |
| 40 - Bernice | Oh! Okay! |
| 41 - Teacher | Ten percent is worth eight M\&Ms. Fifty percent ..., that's half the packet, <br> is worth forty M\&Ms. All right? Does that make sense to you? |
| 42 - Bernice | Yes. |
| $43-$ Teacher | Can you take it from there? |
| $44-$ Bernice | Yes. |

In this way, Bernice is brought to an awareness of how her way of thinking about the task clashes with the logic of mathematics ("Oh! Okay!") (Turn 40) and of how she "can take it from here" (Turn 43), that is, utilise her way of thinking to attain a successful solution. In the process, Bernice is provided with the opportunity to populate mathematical discourse with her own voice, that is, to weave together scientific and everyday notions of what it means to do mathematics into a local discourse that reflects her specific circumstances. From a strictly mathematics perspective, Bernice has the opportunity in this interaction to learn a great deal about the language and practice of mathematics, including a strong desire to inquire and question rather than to seek closure. From a cultural perspective, this discussion between Bernice and the teacher mirrors in many ways the actual practice of the mathematics community where idiosyncratic understandings and concerns are present at various stages of the scientific work, but are obscured in the final product. In this way, the interweaving of different perspectives in the classroom talk may be productive in enabling students, like Bernice, to appreciate the relevance of 'mathematics' in coming to 'know' and 'do' school mathematics tasks.

## Conclusion

The 'replacement' and 'interweaving' patterns of discourse are offered as an initial heuristic, a device, to begin conversations with teachers on how classroom talk may be used by teachers as a tool to assist students to come to know and do school mathematics. Similar to the I-R-E script in that the teacher calls upon and asks students to answer questions, repeats students’ responses and prods students towards preferred understandings, the replacement format differs from the traditional I-R-E script in that it is not viewed by the teacher as the only tool that should mediate teacher student interactions within the classroom. As such, the replacement format can be used to provide students with an ‘idea’, a 'beginning', an ‘initial' understanding so that they can contextualise the learning of mathematical knowledge (e.g., the concept of percentage) within a group/classroom discourse that foregrounds mathematical practices such as 'representing' and 'explaining' and evaluates student products in terms of mathematical norms that relate to 'meaning' and 'clarity'.

The interweaving format provides a tool through which students’ understandings and conventional mathematical understandings may grow together into a hybrid form of meaning making. In contrast to the teacher's role in the 'replacement' format, the authority of the teacher remains less visible in the 'interweaving' format. Within this format, the teacher shares his/her authority with students within a classroom context that values the emergence and voicing of students' ways of knowing and doing.

Either format, replacement or interweaving, provides a sense that classroom talk is about assisting students to make sense of the mathematics being presented to them and about linking students' ideas to the conventions of mathematics rather than about teacher and/or textbook evaluations of students' answers. The focus of the two formats is on extending student participation in mathematics beyond presenting a memorised perspective to exploring how 'cultural tools' such as fractions and percentages may be used as thinking devices and as means to explain and to generate understanding.

Teachers need to be flexible in their use of classroom talk as a tool for promoting participation and development in the learning process. They need to have a variety of discourse formats at their disposal and be able to use them intentionally, to achieve specific learning goals, not only the 'replacement' and 'interweaving' formats that we have analysed, but also the 'contextual privileging' and 'pastiche' formats described earlier. Our aim in this paper has not been to advocate for one or other format of classroom talk, but rather to insist that teachers need to be reflective and critical users of classroom talk. Mediated agency promotes a view of human action which positions mental functioning within systems of collective practice that are culturally and historically situated. The formats that we have described in this paper each have their own cultural histories, and can be linked to various pedagogical practices. Practices which privilege certain ways of acting necessarily also privilege certain ways of thinking because, as we have argued, in a sociocultural view of learning, classroom practices (e.g., the ways in which the teacher and students talk to each other in the learning process) are central to the development of mathematical ways of knowing and doing.

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