Dialogic Practices in the Mathematics Classroom

Catherine Attard
Western Sydney University
<C.Attard@westernsydney.edu.au>

Christine Edwards-Groves
Charles Sturt University
<cgroves@csu.edu.au>

Peter Grootenboer
Griffith University
<p.grootenboer@griffith.edu.au>

Teaching mathematics involves a lot of talking, and dialogic practices are central to most pedagogical practices in mathematics classrooms. Furthermore, for mathematical processes such as ‘reasoning’, ‘explaining’ and ‘mathematical thinking’ to be developed, there is a need for rich and robust dialogic interactions in the classroom. In this paper we investigate the dialogue in a *typical* Year 5 mathematics lesson by analysing the transcript using two different analytical frameworks. While the analysis showed that there were many interactions with nearly half being student turns, it was also evident that almost all the exchanges followed an *Initiation-Response-Feedback* pattern, with a high degree of teacher control. Furthermore, there was little evidence that the dialogic pedagogies of the lesson promoted student development in the mathematical processes. Thus, we content that there is a need to understand the dialogue of mathematics pedagogy, and its impact on students’ broader mathematical learning.

Introduction

In this paper we investigate the relationship between dialogicality in primary school mathematics teaching and student learning as it is experienced in classrooms. There is growing evidence advocating the importance of dialogue-rich interactions for student learning and engagement in classrooms, albeit not a great deal in mathematics. Research in primary schools addressing the impact of instructional dialogues in mathematics classrooms is lacking (Anderson, Chapin & O’Connor, 2011). Additionally, researchers and educators lack a framework for teacher-self assessment analysing the impact of their dialogic strategies on student’s learning of mathematics (Hennessey et al., 2016). In this paper we look at one mathematics lesson through a range of analytic frameworks that establish the nature of mathematical dialogues experienced in the lesson. Through this process we hope to first, provide some preliminary insights into the relative value of each framework for this purpose; and second, to gain some initial understandings of the repertoire of dialogic practices used in mathematics pedagogy.

Literature Review

To ground the investigations presented in this paper, we briefly review the literature related to dialogic pedagogical practices, and the learning of mathematical process.

Dialogic Pedagogies in Mathematics

Educational research across the globe overwhelming suggests that dialogic approaches to instruction provide an educationally productive environment that promotes student learning and engagement (Alexander, 2017). Moreover, current research has shown that the nature and influence of pedagogy in classrooms is comprehensively and persistently dependent on the dialogic patterns at play in the sequential flow of teacher-student exchanges

2018. In Hunter, J., Perger, P., & Darragh, L. (Eds.). Making waves, opening spaces *(Proceedings of the 41st annual conference of the Mathematics Education Research Group of Australasia)* pp. 122-129. Auckland: MERGA.

in lessons (Edwards-Groves & Davidson, 2017). Dialogicality involves repertoires of classroom talk and interaction that promote student participation (Sedova, Sedlacek, & Svaricek, 2016); and as found by Edwards-Groves and Davidson (2017) include questioning by teachers *and* students that provoke thinking, extended responses involving justifications and elaborations, critical evaluation of ideas, and explorations of different perspectives. Nevertheless, observational studies strongly indicate that these features are by no mean firmly embedded in classrooms around the world (Alexander, 2017; Skidmore, 2006). Instead, the Initiation-Response-Feedback (IRF) (Mehan, 1979) identified as the default pattern of classroom pedagogical talk remains dominant in classrooms (Skidmore, 2006). The IRF is centred on closed, leading questions with "low cognitive demand" (Sedova et al., 2016, p.14). Even more significant, is that less is known about dialogicality in mathematics instruction (Anderson, Chapin & O'Connor, 2011).

Research has shown that the significance of dialogic pedagogies is the capacity for teachers to open up classroom exchanges to enable students more time and opportunities for engaging in substantive productive discipline talk. Indeed, dialogicality in lessons focuses on tuning into others' perspectives and the continuous collective construction of knowledge through sharing, listening actively, critiquing, problem-solving, questioning, extending and reconciling contrasting ideas. Importantly, these forms of talk are cumulative and often make links between past and future learning or to wider contexts beyond the immediate interaction. More fully developed pedagogical dialogues have not only been shown to assist student's thinking and learning (Mercer & Littleton, 2007), but are also pivotal for developing students' content knowledge in mathematics through oral language use in discussions (Anderson et al., 2011). Yet, teacher understanding of dialogic approaches across the disciplines is limited (Hennessy, Dragovic & Warwick, 2017).

Dialogue-rich instructional strategies have been shown to be a high-leverage pedagogical tool for both constructing subject knowledge and as a valued process clearly linked with the development critical thinking and productive learning and the connection making between and within subject disciplines (Kazepides, 2012). What is striking is that the research worldwide reporting on the educational potential of participating in dialogues have not resulted in substantial changes in teaching. Rather, studies have consistently shown that in today's classrooms, discourse remains dominated by monologic teaching (Reznitskaya & Gregory, 2013). Further to this, and despite growing international evidence for the educational value of student-student and student-teacher dialogues, researchers and teachers lack an analytic framework for making sense of the form and function of dialogic approaches to instruction (Hennessy et al., 2016).

These issues have particular significance in mathematics education, particularly when it is widely accepted and evident in curricula across the world, that mathematical processes are an integral and important aspect of learning mathematics. While these 'processes' are multi-faceted and variously labelled, commonly they include aspects like *reasoning*, *explaining* and *thinking mathematically* (Clarke, Clarke, & Sullivan, 2012). Research implies that dialogue-rich pedagogical practices are valuable for enabling students to develop mathematical processes, and as such it is important to understand how they are enacted in mathematics classrooms, and specifically how these connect to the development of skills, knowledge and dispositions related to reasoning, explaining, thinking and communicating processes.

The Study

The transcript used in this paper is drawn from a larger corpus of recorded, transcribed and analysed lessons gathered as part of a broader funded four-year critical ethnography investigating educational practices in primary schools (see Kemmis, Wilkinson, Edwards-Groves, Hardy, Grootenboer, & Bristol, 2014). The study was conducted in six purposively selected schools in two regions of Australia in the states of New South Wales and Queensland. The particular lesson transcript used in this article was recorded in a Year 6 primary classroom in a rural school; students are 11 and 12 years of age. The lesson was organised as a whole class mathematics lesson focused on decimal fractions; it continued for approximately 50 minutes in a timeslot before the lunch break.

Data Analysis

For this paper, the data was systematically analysed using two different analytical frameworks for studying classroom dialogues: i) *Engaging Messages* (Munns, 2007); and, ii) the *Teacher Scheme for Educational Dialogue Analysis (T-SEDA)* (Hennessy et al., 2016). Because there is very limited analysis of teacher talk and dialogue in mathematics classes, these schemes are used to show any common themes, factors or concerns across the frameworks, and then to ascertain the affordance and limitations of each scheme.

The Engaging Messages framework (Munns, 2007) describes discourses of power and messages of engagement that form part of classroom pedagogy. The identified discourses of knowledge, ability, control, place and voice evolved from the work of Bernstein (1996) and were shaped into a broader framework for engagement by the Fair Go Project (NSW Department of Education and Training, 2006) prior to being adopted for specific use in mathematics by Attard (2011). Although originally intended as an observation framework, for the purpose of this paper it has been adapted as an analytical tool to interrogate the dialogue in the given classroom scenario against each of the individual messages in order to identify its potential value as a tool to assess dialogic strategies.

The Teacher Scheme for Educational Dialogue Analysis *(T-SEDA)* was developed by scholars from Cambridge University (Hennessy et al., 2016) to delineate the substantive nature of the turn-by-turn interaction patterns in lessons and to analyse the extent to which particular teacher talk moves enable student participation in learning episodes. The T-SEDA framework is intended for teacher professional development and is a modified version of the SEDA piloted in primary science classroom settings in the UK and Mexico. The T-SEDA relies on systematically coding talk moves according to 10 identifiable communicative acts categorised into 10 clusters (noted in Table 1 below).

Analysing the Dialogic Practices in a Mathematics Lesson

In this section we will present two analyses of the same lesson transcript on decimal fractions using the two analytical frameworks outlined. These are now presented in turn.

Analysis using "Engaging Messages"

The transcript of the Year 6 lesson on decimal fractions was coded against the five engaging messages of knowledge, ability, control, place and voice. Although the transcript contained a significant number of interactions (a total of 490 teacher and student verbal exchanges), only 15 examples of engaging messages were identified against the framework. The verbal interactions between the teacher and students appeared to be evenly balanced in instances (student turns recorded 236 times, teacher turns 254 times). However closer inspection of the transcript revealed a pattern of closed questioning that illustrates a heavy emphasis on a ‘question and answer’ structured as the IRF (Mehan, 1979) exchange structure rather than turn-taking that enabled extended student turns conversation or allowing student-student discussion. This pattern indicates a high level of teacher control that has implications for the production of the engaging messages of knowledge, place, and voice. Although continuous interaction is identified as an important element of an engaging classroom (Attard, 2014), the teacher-driven nature of the dialogue did not appear to promote engaging messages in this lesson.

Five examples of engaging messages that represent discourse relating to knowledge were identified. These examples included statements from the teacher that incorporated ‘we’ rather than ‘I’ or ‘you’ statements. However, the following sequences of interaction sees the teacher reverting to a more negative message of knowledge where the knowledge is controlled by the teacher: “...but I told you at the start that it is a hundredths chart”. Other comments coded against the message of knowledge were more positive, demonstrating an intention by the teacher to assist students make connections within their learning, linking previous knowledge. In one instance the teacher’s comment indicated a valuing of the students’ contributions and knowledge: “He’s simplified it, that’s the term that we use when we break it down to a smaller amount. Has he simplified it as far as it could go?”

Messages of ability occurred twice during the lesson, encouraging the students to consider themselves as capable. For example, “I don’t think this will take you very long because I think you’ve got a pretty good grip on it”. Comments such as this indicate a strong knowledge of students’ abilities, an important element in establishing positive pedagogical relationships towards student engagement (Attard, 2014).

The transcript revealed five messages relating to place, promoting feelings of belonging and ownership over learning and providing learning activities that assisted students in making connections in their learning. This incorporated the use of an interactive whiteboard and ensuring all students were given opportunities to use it, and the use of an online tutorial to present a different representation of the mathematical concept being learned. The teacher also made several positive affirmations of students’ abilities with statements such as this: “I think you’ve got a pretty good handle on it”.

Although there were attempts by the teacher to include all students in the talk amidst the 500 verbal exchanges in the lesson, the quality of the dialogue did not appear to promote student voice. As discussed earlier, the question/answer pattern of dialogue did not promote discussion amongst students and while the teacher carefully crafted students into his questions with prompts such as, “Let’s talk about why Lizzie might have thought that it could have been 1.18”, he was still the dominant voice in the classroom, steering the discussion and not allowing the communicative space to be shared equally among students.

The use of this framework as an analytical tool revealed the interconnected nature of the messages and illustrated how the quality of the dialogue can be linked to the mathematical processes that form our mathematics curriculum. The messages seemed to unintentionally hinder mathematical reasoning, problem solving, and communication, yet the closed nature of the responses appeared to provide some opportunities for students to build fluency and some level of understanding amongst students.

Analysis using the “T-SEDA”

The T-SEDA framework was also used to examine the transcript of the Year 6 lesson. T-SEDA makes it possible to delineate the prevalence and particular kind of teacher and student initiated talk moves (noting it was adapted in this analysis to also delineate the frequency of turns initiated by students as well as teachers). Table 1 presents the frequency (presence or absence) of each dialogic code as applied to each speaker's turn; examples from the lesson are provided to offer a distinctive sense of the particular dialogic move.

Table 1
T-SEDA Frequency of Instances

T-SEDA Dialogic Code	Frequency of Instances: Teacher Initiated	Frequency of Instances: Student + (SI student initiated)	Lesson examples (what was said) Tch (teacher) – S (student)
i) IEL - invite elaboration, invite others to build on or clarify ideas	12	3 (SI)	(Tch) "what do you notice Emily's done that's different when she says the number (14.658) compared to the numerals after the decimal point?"; "if it's tenths, what do we visualise what we're doing when we look at tenths?"; "what's he done to turn it into nine over fifty?"; (SI) "Is it base ten?"; (SI) "but you don't need the zero because it's a?"
ii) EL - elaborate ideas, clarify or extend an idea	45	7 (S – in response to a teacher prompt or question)	(Tch) "we can express 2.18 as a mixed fraction"; "he's simplified it, that's the term that we use when we break it down to a smaller amount"; "because it's a non-significant zero"; (S) "It's a fraction that has a whole number and a fraction"; (S) "He's broken it down to decimals"; (S) "[Halving] is dividing by two"
iii) Q - querying, questioning, disagreeing with or challenging other ideas	4	6 (SI)	(Tch) "What thinking's behind - that and it's not 1.18, but I can understand why you thought that Laura. What thinking's gone behind her making that suggestion?" "Do you agree or disagree?" (S) "Why doesn't the whole number change, I thought it should be like 1.08, why doesn't the whole number change?"
iv) IRS - invite reasoning	8	0	(Tch) "why is she right? Why is she correct in putting 0.01 there?"; "Why was that wrong Meg?"
v) R - make reasoning explicit	2	1 (SI)	(Tch) Right, OK, because that's what we've got there. 658 thousandths. There's a subtle difference between how you write it and say it"; (S) "I was thinking about the next number coz"
vi) CA - coordinate ideas and agreement	1	2 (SI)	(Tch) "You didn't used to think that though did you?"; (S) "that was hard work and now they're easy"; (S) "I made a mistake, 'coz when you learn about decimals fractions I thought if you went up by one but now I know"

vii) RD - reflect on activity	1	0	(Tch) "what was the point of that activity? What was it getting you to show Lizzie?"
viii) C - connect ideas to past or future	15	1 (S)	(Tch) "So let's revise what we're doing in maths and what we've learnt about so far through the last part of last week"; "we did greater than less than earlier in the week, so let's see if our knowledge of that has been attained?"; "can you see similarities between this chart to the hundred chart that you would have used in year 1, year 2, Kindergarten, all other years?"; (S) "I wasn't here yesterday"
ix) G – guide the talk, activity and thinking	2	0	(Tch) "Shh, let Meg think"; "think about what they did when you're comparing the decimals you've got to add?"
x) E - express or invite other relevant ideas; respond directly to a question within an IRF	147 + 17 (related to managing a task; e.g. we're gonna do this sheet)	216	(Tch) "We've got the same thing for whole numbers, then we have a what?"; "The first place value is?"; "How would you say that number Elsie?"; "take out a red pen to mark with" (S) "decimal point"; "because it's part of a whole"; "it's ten pieces"; "he halved it"; "no"; "a tenth"; "14.658". ***Note:** the student turns were direct responses elicited by a teacher question as part of an IRF exchange
TOTAL	254	236	

Close inspection of Table 1 indicates a significant variation between the particular kind of teacher talk moves and the student talk. According to this measure, the E (Express or invite) category was the predominant talk move, whereby it was evident that the teacher in this classroom produced almost all invitations and elaborations (E, EL, IEL); closer scrutiny of the transcript revealed these were generally in the IRF exchange pattern. This move almost always required to the students to provide a known-answer response to a teacher question; this occurred 216 times from a possible 236 student turns in the lesson. Here the teacher would initiate a sequence with a question (I) (e.g. "What do we call our number system?"), then a student (generally nominated by the teacher) would respond (R) (e.g. "Arabic number system"), and the teacher (in the next turn) would provide feedback (F) (e.g. "That's right, okay") mostly in relation to the correctness of the response.

In this lesson, it appeared that this turn structure in fact limited the possibility for students to contribute a more extended turn or to initiate a question or invitation themselves. This finding appears to be counter to a dialogic approach whereby student-initiated turns (questions, elaborations or invitations) signify a more dialogic classroom (Edwards-Groves & Davidson, 2017). The frequency of elaboration codes (EL) appear moderately high in this lesson, but it is clear that the teacher produced most of these turns. Instances of guiding (G) and reflecting (RD) turns were not often encountered in this lesson but these instances were almost exclusively produced by the teacher. There were minimal instances of co-ordinating (CA) connecting students to past lessons, experiences, concept or activities (C) by a teacher preformulation. One of the surprising findings was that in a mathematics lesson such as this, reasoning (IRS, RE) moves did not appear more often.

Discussion, Implications and Conclusions

The analysis of pedagogical dialogues has been the focus of research across the globe attempting to understand the nature and role of classroom talk for learning and teaching. It is evident that the two analytic frameworks used in this paper offer some insight into the particular patterns of interaction that constitute this mathematics lesson. While there is not scope in this paper to give a comprehensive analysis of the lesson, there are four notable features from both analytic schemes that raise matters related to classroom dialogue and mathematical learning. First, it was evident that the IRF pattern of talk dominated the lesson; this turn structure appeared to limit the scope for students to develop and indeed produce evidentiary talk and mathematical reasoning beyond providing a predetermined known-answer response. Second, both the Engaging Messages framework and the T-SEDA showed that the teacher controlled the dialogue and, even on occasions when a student did initiate a turn, it was mainly directed to and mediated by the teacher, and predominantly related to clarifying queries related to task completion. This is interesting in light of findings by Edwards-Groves and Davidson (2017) that showed dialogic pedagogies actively and overtly promote student-initiated questioning, extended student-student sequences and turns focused on making meaning of the substantive content of the lesson. Third, allied to the preceding two points, there was no evidence that the lesson dialogue promoted mathematical reasoning or significant explanation to any significant degree. In fact, there was no evidence of the utility and development of any mathematical processes at all. Fourth, it is evident that although these analyses are primarily concerned with the sociality of classroom management as expressed through verbal communication, they do not specifically show, however, how the talk facilitates deeper mathematical understandings by students. Added to this, both systems do not enable a nuanced description of the interaction sequences across the lesson as these pertain to mathematics learning. This means that some distinctive features of the dialogue are overlooked or remain implicit; for example, closer inspection of the full transcript reveals that students rarely built on each other's turns, also many of the teacher's turns were multi-unit, meaning they were extended turns that invited, reflected on and/or questioned a student response *as well as* elaborated a concept more fully (in the form of explicit instruction).

While this analysis was only of a single lesson, for the researchers involved it is in many ways a typical, or at least common type of mathematics lesson. So the concern here is not the occurrence of the teacher-directed IRF classroom pattern of talk (which has an important utility in managing and organising students in lessons), but it was the distinct absence of its connection to mathematics itself that we argue distorts the students experience of it in practice. In fact, it is the prevalence of this turn structure that limits students' capacities for developing deep mathematical knowledge and producing extended turns aimed at deepening reason (for example) about specific mathematics concepts. Given the apparent importance of rich dialogic pedagogies for promoting deep mathematical thinking (Mercer & Littleton, 2007), there seems to be a need for research and development in this space. Obviously there is a need for research beyond one lesson to provide greater understanding about the nature of classroom dialogue in classes in different sites, at different levels, and on different topics. But also, there is a need to understand how different dialogic pedagogies might enable the development of skills, knowledge and dispositions in the mathematical processes. Furthermore, while there is scope for research and development related to dialogic pedagogical practices, perhaps there is evidence here of a deeper issue related to the culture of mathematics classrooms and teacher identity. Specifically, these analyses revealed a strong sense of teacher control. While that may have just been a feature of the single lesson analysed, it is unlikely if more diverse and richer dialogic pedagogical approaches will be effective without a cultural shift that sees control of classroom talk shared in some way with the students.

Acknowledgements

"The Cam-UNAM Scheme for Educational Dialogue Analysis (SEDA: ©2015) was developed by a research team from the University of Cambridge, UK, and the National Autonomous University of Mexico, led by Sara Hennessy and Sylvia Rojas-Drummond and funded through a grant from the British Academy. The original scheme and list of co-creators are available at http://tinyurl.com/BAdialogue."

References

Alexander, R.J. (2017). Towards Dialogic Teaching: rethinking classroom talk, (5th Ed).York: Dialogos

Anderson, N., Chapin, S., & O'Connor, C. (2011). Classroom discussions: Seeing math discourse in action. Sausalito, CA: Scholastic Math Solutions

Attard, C. (2014). "I don't like it, I don't love it, but I do it and I don't mind": Introducing a framework for engagement with mathematics. Curriculum Perspectives, 34(3), 1-14.

Attard, C. (2011). "My favourite subject is maths. For some reason no-one really agrees with me": Student perspectives of mathematics teaching and learning in the upper primary classroom. Mathematics Education Research Journal, 23(3), 363-377.

Clarke, D. M., Clarke, D. J., & Sullivan, P. (2012). Reasoning in the Australian curriculum: Understanding its meaning and using the relevant language. Australian Primary Mathematics Classroom, 17(3), 28-32.

Edwards-Groves, C. & Davidson, C. (2017). Becoming a Meaning Maker: Talk and Interaction in the Dialogic Classroom. Primary English Teachers Association Australia. Sydney, NSW: PETAA

Fair Go Team NSW Department of Education and Training. (2006). School is for me: pathways to student engagement. Sydney: NSW Department of Education and Training, Sydney, Australia.

Hennessy, S., Rojas-Drummond, S., Higham, R., Márquez, A. M., Maine, F., Ríos, R. M., García-Carrión, R., Torreblanca, O., & Barrera, M. J. (2016). Developing a coding scheme for analysing classroom dialogue across educational contexts. Learning, Culture and Social Interaction. 9, 16-44.

Hennessy, S., Dragovic, T. & Warwick, P. (2017). A Research-Informed, School-Based Professional Development Workshop Programme to Promote Dialogic Teaching with Interactive Technologies. Professional Development in Education, 44, 2, 145-168.

Kazepides, T. (2012).Education as Dialogue. Educational Philosophy and Theory, 44(9), 913-925

Kemmis, S., Wilkinson, J., Edwards-Groves, C., Hardy, I., Grootenboer, P. & Bristol, L. (2014) Changing Practices, Changing Education. Singapore: Springer Education.

Mehan, H. (1979). Learning lessons: Social organization in the classroom. Cambridge, MA: Harvard University Press.

Mercer, N. & Littleton, K. (2007). Dialogue and the development of children's thinking: a sociocultural approach. London, UK: Routledge.

Munns, G. (2007). A sense of wonder: pedagogies to engage students who live in poverty. International journal of inclusive education, 11(3), 301-315.

Reznitskaya, A. & Gregory, M. (2013). Student Thought and Classroom Language: Examining the Mechanisms of Change in Dialogic Teaching. Educational Psychologist, 48(2), 114-133

Sedova, K., Sedlacek, M. & Svaricek, R. (2016). Teacher Professional Development as a Means of Transforming Student Classroom Talk. Teaching and Teacher Education, 57, 14–25.

Skidmore, D. (2006). Pedagogy and dialogue. Cambridge Journal of Education, 36(4), 503-514.