An Analysis of Teacher Language in Primary Mathematics: A Comparison of Two Differing Approaches

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Language and communication are a core aspect of teaching and learning in mathematics, and teacher dialogue is central to this. As part of a larger project that explores how mathematics classroom language is impacted by standardised testing, this paper explores how two teachers use language in *redirecting, progressing,* and *focusing actions* in the introduction aspects of two different lesson types. The data suggest that the lesson intentions lead to very different interactions of dialogue, and this dialogue in turn points to different approaches to teaching mathematics.

Introduction

Research, such as that carried out by Thompson and Harbaugh (2013), Lobascher (2011), and Polesel, Dulfer, and Turnbull (2012), suggests that standardised testing has an impact on classroom practice and pedagogy. However, the subtleties of how this impacts on practice and pedagogy and how it manifests or varies between different schools is not explicit. While there has been research on the effects of the National Assessment Programme, Literacy and Numeracy (NAPLAN) on curriculum and pedagogy in relation to literacy (Comber, 2012), little has been done on numeracy (Carter, Klenowski, & Chambers, 2016). In this paper, the introduction of two different lesson types, as identified by the researcher, is analysed to investigate how dialogue and communication is being used by the teacher and how this relates to the pedagogical intentions of the lesson. The data analysis in this paper is part of a larger project that investigates how teachers and students are using dialogue and communication in mathematics lessons, and how this is impacted, if at all, by standardised testing such as NAPLAN.

Literature Review

Today's digital age requires *21st century skills*. In mathematics education this means a move from acquisition of knowledge to mastery of knowledge (Barak, 2017), a focus on reasoning, thinking mathematically, and an ability to think flexibly and creatively (English & Gainsburg, 2016). Reasoning is a crucial part of understanding and thinking mathematically (Sullivan & Davidson, 2014) and hence language for, and communication in, mathematics must be a core aspect of teaching and learning. Language is prioritised in the Australian Curriculum through the mathematics proficiency strands (*Problem Solving, Reasoning, Understanding, and Fluency*). These proficiencies are a crucial part of thinking mathematically and their inclusion foregrounds language and communication in mathematics (Sullivan & Davidson, 2014). This refocus on reasoning in mathematics is evident in both national and international mathematics curricula (Clarke, Clarke, & Sullivan, 2012) and moves away from traditional 'chalk and talk' methods to engaging students in reasoning and communication of mathematics.

Understanding language in the mathematics classroom is therefore important, and dialogue and communication are essential in creating teaching environments that promote student learning (Attard, Edwards-Groves, & Grootenboer, 2018). Using language as a tool for thinking enables learners to make sense of concepts, this 'interthinking' is key (O'Keeffe & Ní Ríordáin, 2012) as knowledge and the words used to express this knowledge cannot be

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separated (Mercer, 2000). Discussion, dialogue and discourse are well established as being important in education. For example, Vygotsky (1973, cited by Moll & Whitemore, 1993) identified the manipulation of language as essential in learning, with a particular focus on the means of communication - which is referred to as the *school discourse*. In mathematics, this discourse has been unpacked in different ways but Halliday (1978) provides a comprehensive understanding of mathematical discourse by means of the mathematics register, by which he intends to mean more than just terminology but also the meanings, styles, and modes of language as it is used. Communication in mathematics is more than just mathematical language itself, it encompasses everyday discursive practices such as interactions, activities and dialogue through which the language is used. Taking Franke, Kazemi, & Battey's (2007, p. 230) perspective of the development of mathematical understanding as one which "requires that students have the opportunity to present problem solutions, make conjectures, talk about a variety of mathematical representations, explain their solution processes, prove why solutions work, and make explicit generalizations", then one would expect classroom discussion or dialogue to be one that is language rich and not dominated by an initiation–response–evaluation (I-R-E) pattern of communication.

According Cazden (2001) and Skidmore (2006) the I-R-E pattern remains the dominant dialogic pattern in classroom communication, and more recently Attard et al. (2018) also found I-R-E to be the dominant pattern in mathematics lessons. Franke, et al. (2007) argue that within an I-R-E pattern students tend to be limited to discourse related to procedures, focusing on answers and methods, rather than working through an idea or explaining their thinking. However, Wells (1993) warns that aspects of interactions may be hidden in I-R-E patterns and that there may actually be more room for student thinking and sharing than identified in some literature.

Research Design

The larger study was conducted in four primary schools purposively selected from samples of schools identified as low, mid and high SES according to their ICSEA (Index of Community Socio-Educational Advantage). The final sample includes one high SES R-12, two mid SES R-7 and one low SES R-12 school. One Year 5 teacher and their students, at each site, participated in this study. The data collected throughout the project includes:

- A pre-project teacher interview,
- A minimum of five lesson observations at each site, which include researcher and research assistant (RA) field notes, audio recordings of the lessons, including lesson plans and teacher post lesson reflections,
- Post-project teacher reflection (in writing), and
- Student NAPLAN data and assessment samples.

This paper focuses on two teacher case studies, detailing an outline analysis of the introduction phase of their first lesson observation as part of this project. Their post-lesson reflection is also discussed. The data were transcribed and analysed in NVIV011 for key themes. Data collected in the lesson observations include artefacts (such as worksheets, pictures of student work samples), researcher field notes and audio files. In this paper only the analysed audio file data are included. These audio files were transcribed and coded against the adapted Drageset's (2014) *Redirecting, progressing, and focusing actions framework* as presented in Figure 1 below.

Following the sample method used by Drageset (2014, p. 289) where teacher-led dialogue was analysed as a conversation in itself, "not as a window through which we can view other processes", this paper investigates two lesson extracts, coded as I-R-E to unpack

the detail behind this coding. Drageset's (2014) framework (left hand side (LHS) of Figure 1 below) for describing how teachers use student responses is applied to analyse both lesson extracts. This framework comprises three key categories, each of which are further broken down as per Figure 1 (LHS) below. However, analysis of the data identified one additional category that appears to have been covered in Drageset's framework and this added element has been labelled *logistics*; where the teacher gives logistical directions or instructions to support an activity. Also, some clarity was needed within categories. For example, in the category *notice* more detail (see right hand side (RHS) of Figure 1 below) was added to make it clearer what the teaching was actually referring to as this appeared to point to their teaching preferences. Additional modifications were also made to Drageset's framework to create a more mathematical focus.

Drageset's Framework (2014)

1. **Redirecting Actions**
   a. Correcting questions
   b. Put aside
   c. Advising a new strategy
2. **Progressing Actions**
   a. Demonstration
   b. Simplification
   c. Closed progress details
   d. Open progress initiative
3. **Focusing Actions**
   a. Request for student input
      (i) Enlighten details
      (ii) Justification
      (iii) Apply to similar problems
      (iv) Request assessment from other students
   b. Pointing out
      (i) Recap
      (ii) Notice

Modified version of Drageset's Framework

1. **Redirecting Actions**
   a. Correcting questions
      (i) OK, but…
      (ii) Try again
   b. Put aside
   c. Re-direct to new strategy
2. **Progressing Actions**
   a. Demonstration
   b. Simplify - provide a prompt
   c. Simplify - provide a strategy/method
   d. Closed questions
   e. Open questions
3. **Focusing Actions**
   a. Request for student input
      (i) Clarity sought
      (ii) Justification
      (iii) Apply to similar problems
      (iv) Request assessment from other students – teacher consensus
      (v) Request assessment from other students – student consensus
   b. Pointing out
      (i) Recap
      (ii) Notice – content
      (iii) Notice - behaviour
      (iv) Notice – achievement

Figure 1. Adapted version of Drageset's (2014, p. 302) framework (RHS) and modified version of Drageset's framework utilised in this study (LHS)

The Teachers

Eve (pseudonym), graduated in 2014 as a primary teacher with a specialisation in mathematics. She describes herself as confident in her mathematics, she enjoys reading and upskilling in regard to teaching mathematics, and takes up opportunities to engage in mathematics whenever she can. In regard to her teaching, she is proud of her work and she finds teaching mathematics rewarding. She is impressed by the quality of thinking of her students and feels that her efforts to engage and inspire them in mathematics is appreciated by them. However, she does not feel this is appreciated by her colleagues. When asked about her general approach to mathematics teaching, Eve replied saying how important it is to

engage children. She indicates that she generally takes an inquiry-based approach to her mathematics teaching, trying to begin by posing questions and letting students take the initiative.

> I'll continue questioning them so they can justify how they got to, like reasoning …I feel like there is a really negative disposition [around mathematics] so it needs a lot of encouragement. You need to be really excited when you introduce maths because kids are sitting there with a negative mindset as soon as you say oh its maths, and I feel like a lot of teachers say it. It could be something as simple as, once you finish your maths you get to do something fun like art, saying that maths isn't fun. So, putting a fun spin on it really helps out with the games … kids get to realise oh it's not just writing out your times tables.

Eve explained that she tries to be really 'hands-on' in mathematics, for example:

> This morning I was just focusing on maths language, and they got a zip lock bag with six cue cards and some had seven unifix blocks and some had six unifix cubes. [The idea was to] focus on the language that was on the cards so that students had to build something. So, it was called cooperative logic, building using unifix cubes and they were just in groups working together to try and build an object that they didn't have a picture of just [the language describing it] using the cubes.

Eve teaches in Year 5 in an R-12 school considered low SES with 915 students and an ICSEA value of 915. She has her 30+ Year 5 students in a classroom designed for 25 (there is very limited moving room in this classroom), the air-conditioning unit is unreliable, and she is continually asking for resources, spending much of her weekends creating 'packs' of equipment for class.

Kate (pseudonym), graduated in 2013 as a generalist primary teacher. She describes herself as confident in her mathematics and considers her mathematics to be one of her strongest teaching areas. Kate also describes herself as enthusiastic about mathematics teaching, enjoys teaching Year 5s but is unsure if she would choose to be teacher if she had her time at university all over again. Kate enjoys upskilling in mathematics but does think that teaching mathematics is hard work. Kate does not think her students or their parents appreciate the work she does in mathematics, but her colleagues do to some degree. When she was asked about her general approach to mathematics teaching, Kate replied saying:

> I think it's important and I enjoy teaching it [mathematics]…. I feel interested teaching it and it is one of those subject areas that you can really track progress with kids as well so generally… measurable in that you're taking kids from one point to another and once they've got that concept and if they can apply that concept then you know you can move on.

Kate explained that she tries to encourage discussion in her mathematics lessons and below is her response to giving an example of her typical approach to mathematics teaching:

> I do a lot of discussion with the kids …I like to teach in a way where they teach each other lots of things and they share what they know, what they like, what they don't like. I like kids to have an opinion … I like to start from the basics and go through you know what they already know and check what they already know… I will provide card games, dice games, basic just rote learning, write them out, say them, sing them, draw them whatever it is so I'll give that range of options so it's not just this boring, tedious go home and write them out 25 times. Also, I'm incorporating a lot of digital technologies so just this week especially I've introduced them to a few programs that they can then go home and use and do at home as practise.

Kate is teaching in an R-7 school considered mid to high SES with 781 students and an ICSEA value of 1107. Kate has 29 students in her classroom but has a small floor space at the front to enable some children to come to the front and sit on pillows to work on problems. She also has a row of computers against one wall.

During the interviews, both teachers were asked, on hard copy, to respond to a number of statements using a 5-point Likert scale, of *Strongly Agree* (5) to *Strongly Disagree* (1),

Figure 2 is intended to provide an overview of some of the differences in regard to perspectives of the two teachers.

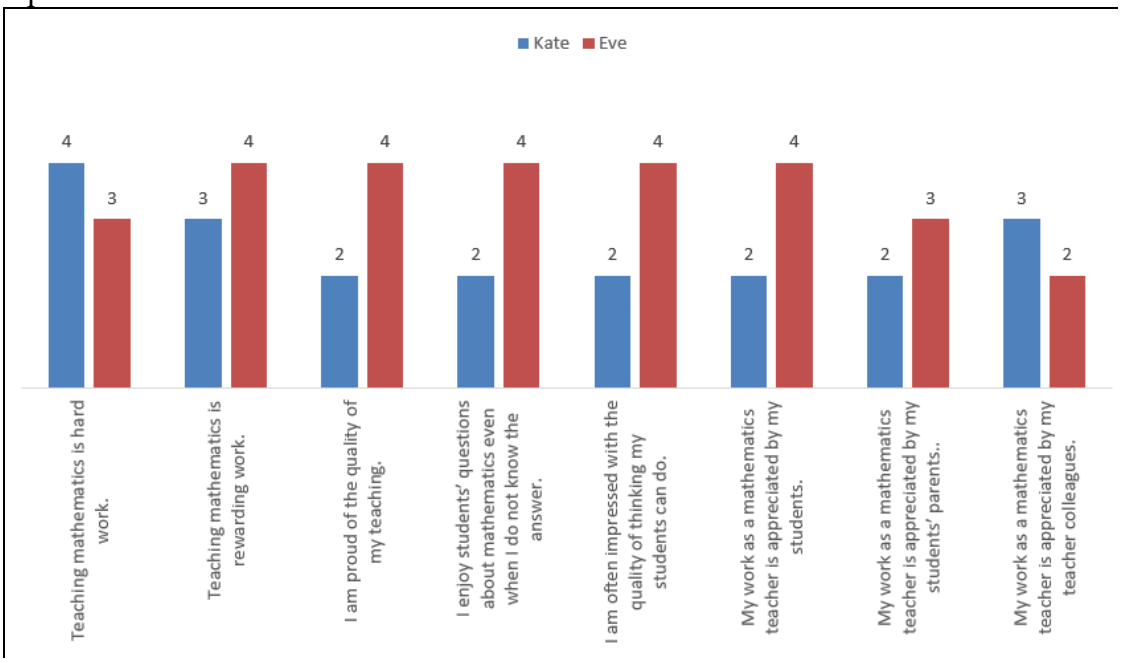

Figure 2. Mini-survey responses from interview teachers.

Findings

Audio of Observations: Lesson One, Introduction Phase

The transcript of the introduction of Eve and Kate's first lesson observation was coded against the adapted Drageset framework. Eve's lesson introduction lasted for just over 17 minutes, while Kate's was over 17.5 minutes, however the first 10 minutes of this was quiet writing time on a pre-identified topic, so only 7.5 minutes was directly related to the introduction of the actual lesson. Table 1 provides an overview of the frequency of the different themes (from the framework) that presented in the lesson introduction.

Table 1
Overview of frequency of themes

	Total number of instances	Number in Eve's lesson	Number in Kate's lesson
Closed questions	50	15	35
Logistics	21	17	4
Open questions	15	14	1
Notice – achievement	12	8	4
Correcting questions – try again	11	1	10
Demonstration	6	2	4
Simplify - provide a strategy/method	4	4	0
Correcting questions - ok but…	3	1	2
Simplify - provide a prompt	3	3	0

Looking at the most frequently themes in both of the lesson introductions allows for some determinations to be made in regard to the type of lesson both teachers were undertaking. For example, Kate's lesson introduction appears to have a focus on her asking closed questions and also correcting student answers. Her lesson extract only includes one open question. The balance of questions, between open and closed, suggests that this lesson might be very teacher-led, which in this case is true. Kate's lesson, from the researcher's perspective, is a revision of long multiplication. Kate describes the purpose of this lesson as being focused on "*practice questions to get ready for NAPLAN*", where she wanted students to familiarise themselves with specific questions and work on developing strategies. In her post-lesson reflection, Kate indicated that this lesson had "*more instructional dialogue and guidance from the teacher than independent learning*" and that this is the type of lesson she would use often. In this lesson, Kate used closed questions to talk her students through examples, one step at a time. Drageset (2014) suggests that a teacher might use this approach to ensure that all students can follow the line of thought of a process or procedure. In this case, Kate is very much focused on the method and is also using this strategy as a behaviour management technique, asking specific students who appear (from the field notes) to be going off-task to answer the question, for example:

T: It's long multiplication which, which means I'm going down length ways down the page, it's going to be a long sum. Alright what's the next step?
S1: 2 times 9.
T: 2 times 9. Which is what?
S2: 18.
T: Alright what do I do?
S3: You put the 8 down; well you add the 3 to the 18.
T: I add the 3 to 18 which is going to give me what?
S4: 21.

The majority of Eve's dialogue in her lesson extract is centred around four different themes: closed questions (15 instances), logistics (17 instances), open questions (14) and making a point of student achievement (8). The spread across these four themes suggests a very different classroom experience than that of Kate's lesson. Eve describes her lesson focus as "*measurement – misconception between perimeter and area: If the perimeter is 20cm the area will always be the same*" where she wants the students to learn to choose appropriate units of measurement and understand and calculate perminter and area of rectangles. Eve's lesson was very interactive with students making suggestions, drawing different examples and sharing ideas with each other and with Eve throughout the introduction. In her use of open questions, Eve asks some rhetorical questions, intended to direct the students thinking. However, the majority of her open questions are directed to the class or individuals in relation to extending their thinking about a particular example/task at hand, such as "*Could we work out a way that they are all 30 centimetres? Toby?"* According to Eve, this approach is typical of her everyday mathematics lessons. In her post-lesson reflection, Eve indicated that the only difference in the observed lesson from her typical lessons was that she was trying out a new grouping strategy that day but in general this type of lesson is the common approach that she uses.

Following completion of their lessons, both Eve and Kate completed a post-lesson reflection. In this reflection they were asked a series of questions about their intentions for the lesson, their approach and how they planned for the lesson. Eve and Kate were both asked to indicate (on a given list, which had options for them to add to) the different resources and sources that impacted on how they planned their lessons. Eve indicated that

her key resources were her teacher textbook (which is the one she purchased during her university training) as well as ideas from the Professional Development (PD) she is attending. She also noted that she used knowledge about her students' interests and the ways they work as well as the Australian curriculum. For Kate, the only resource/source she made use of for her lesson planning was *external examinations or standardised tests,* which in this case is NAPLAN numeracy assessments. Despite these lessons being at the same time of the year, (first week of April) both of these teachers appear to be responding very differently to the upcoming NAPLAN numeracy tests, with Kate placing this very clearly and explicitly at the fore of her decision making.

Discussion, Considerations and Conclusion

The two I-R-E patterns of dialogue analysed in this paper demonstrate Franke, et al.'s (2007) concern that an I-R-E limits discourse to procedures, answers and methods but also Wells' (1993) concern that patterns of student thinking can often be hidden in I-R-E. Kate's data presents a straightforward I-R-E teacher-directed dialogue, where the focus is solely on working through the steps of a particular procedure. While Eve's lesson extract comprises mainly of I-R-E patterns of discourse, there are more opportunities for student thinking and sharing. Her even spread of open and close questions is one key indicator of this as is her inclusion of different strategies and approaches to the task at hand. While on the surface level an initial I-R-E classification can be useful, it can be oversimplified, as argued by Wells (1993). Hence, he suggested I-R-F rather than I-R-E, as he believes that the classification of 'evaluation' is much narrower than 'follow-up'. The data here supports this in some ways, but also points to the need for such classifications to include multilayered analysis to ensure that opportunities for extending or promoting thinking, and not masked by the words of a dialogue taken out of context.

Giving the limited sample size analysed in this paper one cannot make any generalisations and connections between the type of dialogue/communication that is being encouraged or prioritised as a result of NAPLAN. However, these data do provide a very good starting point for this discussion. There are clear differences in relation to access to materials, classroom size and space and the approaches taken by both of these young teachers. In her pre-interview, Eve spoke about her preferred approaches to teaching mathematics and there was evidence of this in her analysed lesson extract. Despite the extract being only a 17-minute introduction to her lesson, there was evidence of a range of approaches from her dialogue. In fact, Eve had at least one instance of each of the elements of the adapted framework and demonstrated an almost even approach, between open and closed, to her questioning. In contrast, in her pre-interview Kate spoke a lot about creating opportunities for discussion. However, the analysis of her 17.5-minute introduction, which including 10 minutes of silent work, suggests a preference towards closed questions. A key difference between the dialogues analysed was the lesson intention. Eve wanted to focus on student thinking, while Kate wanted to focus on students practising a particular method. While NAPLAN may well be a contributing factor in the differences identified in these lesson intentions, it is not the only factor as both Kate and Eve indicated that these lessons very fairly and very typical (respectively) of their usual teaching.

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