Peer Collaboration in Early Years Mathematics: A Linguistic Analysis

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In this study, we aim to investigate the role of language in small group peer collaboration. Based on the notion of symmetrical scaffolding, we draw on theories of dialogic space and functional linguistics to analyse a transcript of three six-year-old students as they explore a shared understanding of 'two more than'. Using Martin and White's (2005) engagement framework as an analytical tool, we identify how the three students used language resources in contractive and expansive ways to move each other's learning forward. These findings provide a perspective of symmetrical scaffolding closely focused on students' language choices that support engagement with each other's thinking. We suggest that a focus on use of language with young students is valuable in identifying the type of mathematical discourse that will support peer collaboration in problem solving and mathematical reasoning.

Small group work is often seen to benefit students in learning mathematics where there is potential for students to develop mathematical reasoning and problem-solving abilities. Studies that analyse small group work in mathematics are still few but key elements of such studies modelled how students share their mathematical point of view (Schoenfeld, 1992), investigate socially mediated metacognition in relation to Vygotsky's Zone of Proximal Development (ZPD) (Goos et al, 2002), or identify types of productive talk (Mercer & Sams, 2006). Despite the acknowledgement of the role of language in such studies, direct analysis of students' choice of language to share mathematical points of view are less well known.

In this paper, we base analysis on a functional use of language to identify how students' choice of words play a role in symmetrical scaffolding in learning mathematics. Whilst scaffolding has been defined as "the process that enables a child or novice to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts" (Wood, Bruner, & Ross, 1976, p. 90), we bear in mind that the basis of this definition stems from studies on how adults help children learn language through playful games. Hence, we propose that use of language is particularly salient with students in early mathematics classrooms who are in nascent stages of engaging in the discourse of mathematical reasoning and problem solving. To illustrate this premise, we present an example of analysis based on functional linguistics from a group work of three Grade 1 (six-year-old) students as they work together to share mathematical points of view in finding 'two more than'.

Key Literature

Scaffolding is more often used with reference to teacher and student interactions and Vygotsky's Zone of Proximal Development (ZPD) has often been generalised to support from "more knowledgeable others". Both of these suggest an asymmetrical relationship. However, several studies have related scaffolding and ZPD to peer collaborative learning. Forman (1989) investigated how students' different perspectives of a problem are coordinated through group work as they explored each other's reasoning, attended to another's viewpoint, and potentially changed another's mind. Goos et al's (2002) study took a socially mediated metacognitive approach in relation to symmetrical scaffolding and suggested that, in peer collaboration, all students had some knowledge. Whilst the knowledge may be incomplete and relatively equal, the contribution of each group can

(2023). In B. Reid-O'Connor, E. Prieto-Rodriguez, K. Holmes, & A. Hughes (Eds.), *Weaving mathematics education research from all perspectives*. *Proceedings of the 45th annual conference of the Mathematics Education Research Group of Australasia* (pp. 379–386). Newcastle: MERGA.

move knowledge forward. Forman also referred to this as one student's response 'pulling' another student into the zone.

Such perspectives are useful in modelling a symmetrical perspective of ZPD, but they do not focus on the way language is used to attend to and potentially change another's mind. Teasley and Roschelle (1993) once stated that collaboration is "a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of the problem" (p. 235). This notion of shared conception resonates with Schoenfeld's (1992) shared mathematical point of view. A shared conception or point of view is a fundamental characteristic of a dialogic space, a space where multiple ideas are explored and in which students "think and act collectively" (Wegerif, 2018, p.2). Within such a space, there is a process of "mutual attunement" or resonance of ideas (Wegerif, 2013). Participants are open to each other's ideas. Littleton and Mercer (2013) further defined dialogic space as a co-constituted linguistic process where students are engaged in iterative negotiations of shared meanings. As such, the function of language within a dialogic space is not just for co-location of individuals, but for shared meaning.

These notions suggest that the exploration of multiple ideas requires the opening of a dialogic space in which students can "think and act collectively" (Wegerif, 2018, p.2), and that language is intrinsic to this exploration. Hence, we build on Littleton and Mercer's assertion that the process of opening a dialogic space is linguistic and we assert that the opening of a space to explore meaning relies on students' choice of language. Some choices of language could open a space and others close it down. What is not known is how students' linguistic choices influence the opening and expanding of dialogic spaces. Finding a way to analyse the opening and closing of dialogic spaces, could help determine the effectiveness of talk to share thinking within group work.

Hence, we ask the question: In what ways can a linguistic analytical approach determine how students use language in small group work to share meaning in mathematics? To answer this question, we bring together facets from scaffolding and ZPD with the notion of dialogic space in examining the functional use of language in small group collaborative work. The aim is to explore how language is used by the students to 'pull' each other into the zone.

Methodology

Halliday and Matthiessen's (2004) work on systemic functional linguistics (SFL) sees language as meaning oriented and embedded in a social context. Martin and White's (2005) engagement framework, based on SFL, is used in our study to analyse the semantics of young students' language within small group work. Martin and White's framework draws on Bakhtinian notions of heteroglossia and monoglossia. Monoglossia refers to talk that deals with one voice and one big idea (Bakhtin, 1984) and relates to discourse that is one-sided, rationale, and singular (Roth, 2009). Terms that are monoglossic do not seek to engage, they state facts (e.g., *so, 6 add 2 is 4* or *that accounts for…*). These terms do not leave space for negotiation. Terms that are heteroglossic seek to engage in multiple or possible ideas in a way that confronts, challenges, and transforms learners' ideas (e.g., *I think…* or *it could be...*). Our premise is that talk in small peer groups enables multiple ideas to be explored. Rather than "expounding already found, ready-made irrefutable truth" (Roth, 2009, p. 94), students with equal and incomplete knowledge are still determining "the truth," that is, a shared meaning regarding a mathematical idea.

Martin and White's engagement framework refers to monogloss and heterogloss in determining how language choices expand or contract the dialogic space. In this study, we focus on part of the framework that deals with linguistic terms that are heteroglossic in nature (Figure 1). Whilst dealing with multiple ideas, heteroglossic terms can be contractive in that they disclaim by denying (*no, never*) or countering (*yet, although*) or proclaim by concurring (*of course*), pronouncing (*indeed*) or endorsing one idea (*this proves that*). Heteroglossic terms can also be expansive in that they entertain

alternative ideas (*it's possible that*) or attribute to existing knowledge (*the report states that*). It would seem that linguistic terms that are expansive are those most likely to open dialogic spaces and allow for students to share mathematical points of view and, hence, pull a student into the zone.

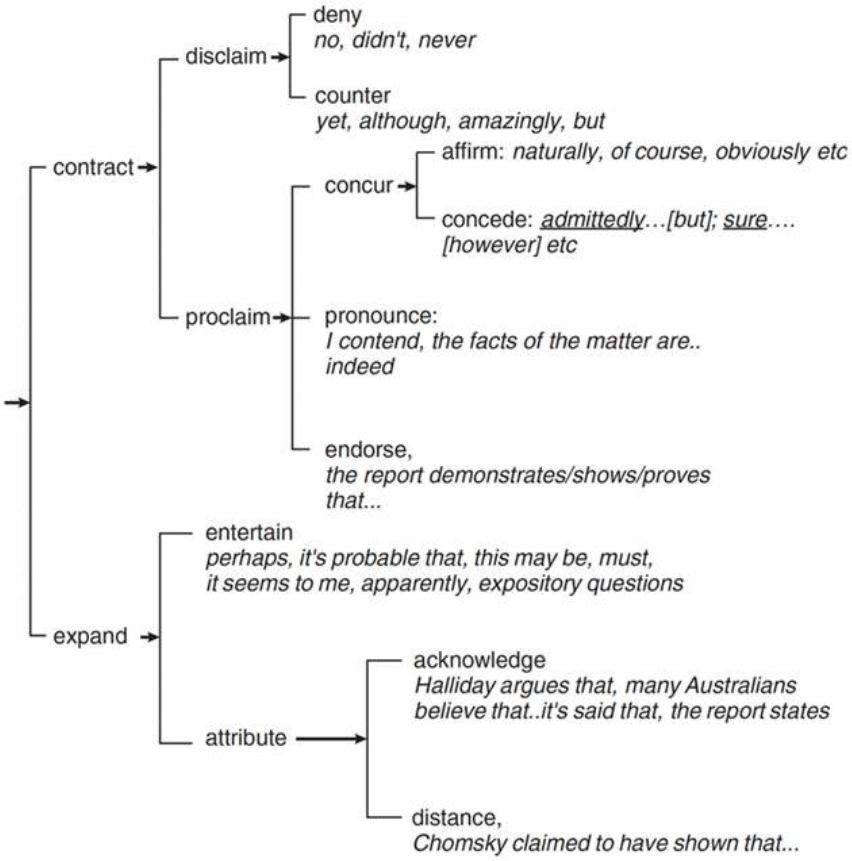

Figure 1. The engagement framework: Heteroglossia (from Martin & White, 2005, p. 134).

In this paper we present an extract of a transcript taken from a study in New Zealand where the researcher worked with one teacher over a year to introduce tasks to encourage collaborative talk amongst Grade 1 (six- to seven-year-old) students. The teacher and researcher had determined that, whilst the students were able to answer 3 + 2 confidently, they were not confident in the notion of 'two more than three'. Such lack of confidence is not unsurprising and suggests that the students are working within an operational view rather than a relational view of arithmetic (Stephens, 2006). The transcript is taken from a video recording early in the study towards the end of the first term focusing on one group of three Grade 1 students, Kim, Emma, and Helen (pseudonyms). Initial attempts to encourage the three students to work on such problems had not elicited any talk or agreement. It was decided to re-introduce the problem with visual representations, in this case ten frames (Figure 2). Ethical approval was obtained based on the university's ethical protocol. Teacher and parental consent were obtained as well as oral assent from the students involved.

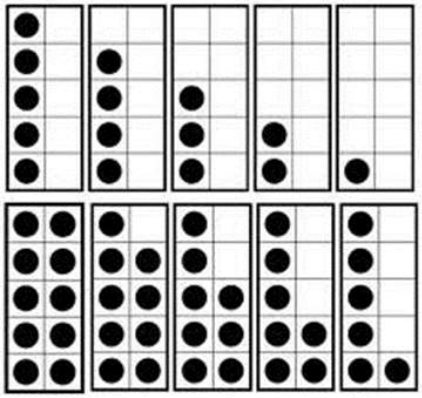

Figure 2. Set of ten frames.

Analysis and Results

The three students, Kim, Emma, and Helen were asked by the researcher to order a set of ten-frames from one to ten. The three children were successful in ordering the ten-frames and were able to state that each card had one more dot. The researcher then introduced a task to order the ten frames so that there are two more each time. To start, the researcher placed the one ten-frame on the table and asked the students which ten-frame would have two more than one. Helen and Emma thought the two ten-frame would be next, but Kim thought it should be the three ten-frame. The researcher asked Kim to explain why she thought it should be three and not two. The remaining dialogue is presented as a transcript below and is analysed using an adaptation of Martin and White's framework (Table 1).

Table 1

Adaptation of Martin and White's Engagement Framework

Heteroglossic terms		Examples
Contract	Disclaim	Deny: No; No, it has to be…
		Counter: But it has to…
	Concur	Affirm: I think she's right
	Proclaim	Pronounce: I've got…
Expand	Entertain	I think it might be…; See, I've got…

1	Kim:	But it *(points to the 2 ten-frame)* has got one more on it, not two more on it. **DISCLAIM: COUNTER** You have to say two more added, **PROCLAIM: PRONOUNCE** like you're skipping one, like you're counting in twos. **ENTERTAIN**
2	Helen:	I think she's right because she's just skipping the two and it's going onto that one *(points from the one to the three ten-frame)*. **CONCUR: AFFIRM**
3	Emma:	I think it's right. **CONCUR: AFFIRM**
4	Researcher:	If that's got two more than one *(pointing to the 3 ten-frame*), what's going to come next? *(pointing to the space following the ten-frame)* **ENTERTAIN.** It's got to have two more on it. *(Moves away from the table.)* **PROCLAIM: PRONOUNCE**

5 Helen: *(Reaches over to 2 ten-frame but does not pick it up.)* Two. **MONOGLOSS**
(Emma Picks up 2 ten-frame and then puts it down in front of her.)

6 Helen: *(Looks at other ten-frames in front of her.)* No. **DISCLAIM: DENY**
Four, four, four. I've got four, I've got four. **PROCLAIM: PRONOUNCE**
(Emma picks up 4 ten-frame and hands it to Helen (Figure 3).)

Figure 3. Emma hands 4 ten-frame to Helen.

7 Kim: *(Moves 5 ten-frame in line next to 3 ten-frame and counts the dots on the 5 ten-frame (Figure 4).)* I can put two more on it. See one, two, three and then two more. Five. **ENTERTAIN**

Figure 4. Kim counts dots on 5 ten-frame.

8 Helen: Yes, that's five. **CONCUR: AFFIRM**

9 Researcher: You've all got to agree which ten-frame goes next. (*To Kim.*) You have to persuade them which ten-frame goes next.
(Kim looks at Emma. Emma has 4 ten-frame in her hand and looks at it. Kim moves the 5 ten-frame away from the line but keeps it under her hand. Emma places the 4 ten-frame on table, near the line but not next in line (Figure 5).)

Figure 5. Emma places 4 ten-frame next to the 3 ten-frame.

10 Kim: (*Points to the 3 ten-frame and then the 5 ten-frame.)* There's three on this line and three on this one but two more on it. *(Kim and Emma look at each other. Kim puts the 5 ten-frame next to the 3 ten-frame in line (Figure 6).)* **PROCLAIM: PRONOUNCE**

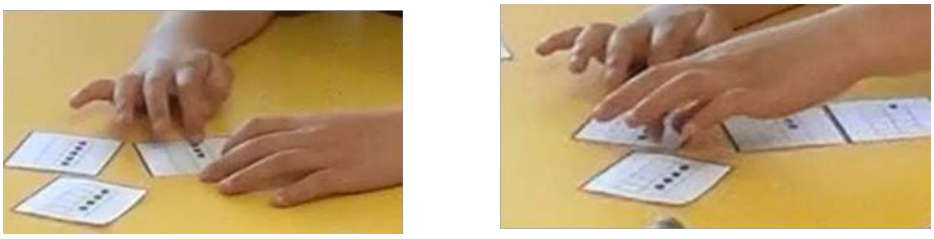

Figure 6. Kim puts the 5 ten-frame next to the 3 ten-frame in line.

At this point the children are silent. Their eyes look down towards the table or around the room. This lasted for forty seconds. From the observer's perspective, it is not clear if the students are still considering whether 5 is two more than 3, but then Helen entertains an idea to continue the task of 'two more than' without being asked.

11	Helen:	*(Moves forward in her chair and looks towards Kim.)* I think seven. **ENTERTAIN**
12	Kim:	*(Looks towards Helen.)* Uh… ha? **ENTERTAIN**
13	Emma:	*(Looks at Helen.)* I think seven too. **ENTERTAIN**
14	Helen:	Now we have to figure out which one is seven. *(All three children look through the ten-frames to find the 7.)* **INSTRUCTIONS**
15	Emma:	Seven *(picks up the ten-frame and hands it to Helen, who then hands it to Kim)* **MONOGLOSS**
16	Helen:	Seven, do you all agree? Kim do you agree? **ENTERTAIN** Emma? **ENTERTAIN** *(Emma nods head).* **CONCUR: AFFIRM** I think it's right *(Helen turns to look at Researcher)* **ENTERTAIN**
17	Researcher:	Ok, so what do you think will come after seven then? **ENTERTAIN**
18	Helen:	Nine **MONOGLOSS**
19	Kim:	Yes nine (Helen places the 9 ten-frame.), **CONCUR: AFFIRM** and then eleven, …if we had an eleven. **ENTERTAIN**

In determining the results, we present a descriptive commentary on the students' (and the researcher's) dialogue. Initially (lines 1 to 3), students use dialogical contractions in the form of disclaim and concur. Kim denies the ideas of the other two students (*But it has got one more on it, not two more on it*) and then uses the modal term 'have to' in proclaiming and pronouncing that two have to be added. She then illustrates this with entertaining the notion of 'skipping one.' Kim's entertainment of skipping one appears to pull Helen into a shared idea and she uses similar terms regarding 'skipping' and 'going on to' to establish a shared understanding of two more than. Emma nods in agreement but at this point it is not clear how well her gesture of concurrence is related to a shared understanding.

The students then move to find two more than three. Despite what seemed like a shared understanding, when asked to find two more than three Helen states two (line 5) almost as a fact and Emma follows by placing the two ten-frame. However, Helen than disclaims her own thinking and pronounces 'I've got four'. Emma follows the pronouncement and hands the four ten-frame to Helen. Kim (line 7) then moves the five ten-frame. Kim's use of modality 'I can put two more on it' suggests she is entertaining an idea to be shared with the group. This is then affirmed by Helen (line

9). Whilst not saying anything, Emma still holds the four ten-frame, possibly suggesting that she does not concur with the Kim and Helen, and the researcher prompts Kim to share her thinking further with Emma. In line 10, Kim contends that five is two more than three, pronouncing 'there's three on this…' whilst pointing to and comparing the five ten-frame with the three ten-frame indicating the two more with her fingers.

It is not clear if Emma concurs with the shared viewpoint, but Kim seems to have pulled Helen's thinking forward to the extent that Helen now takes the lead with a leap to further entertain seven being next in the continued sequence (line 11), albeit after a gap in the dialogue. This leap was not instigated by the researcher or the other students, but it seems that the relational structure of 'two more than' is generalised further and Helen now pulls Kim (*Uh… ha* line 12) forward into the shared thinking and possibly Emma as well *(I think seven too* line 14). It now seems that all three students are entertaining a shared idea. The researcher then asks what would be next after seven and nine is given as a fact or a truth now known by the three students, however the students continue to entertain ideas beyond the known fact suggesting a secure shift in thinking towards relational thinking.

Concluding Remarks

The analysis of the transcript based on Martin and White's (2005) engagement framework has enabled the determination of language choices by young students that support peer symmetrical scaffolding within small groups. Whilst confirming previous findings that symmetrical scaffolding can support learning in mathematics, such as Goos et al (2002), the analysis provides a fine-grained examination of how language is used to share the equal but incomplete knowledge of peers, and then used to draw each other into the zone or shared meaning.

The dialogue started from a basis where one student, Kim, had some understanding of the relational thinking. Through her use of language (and gestures) she pulled the other two students into the zone by using language that entertained ideas, to the extent that Helen then took the lead. Use of Martin and White's (2005) framework helped to understand how both expansive and contractive terms were used to create a dialogic space. It seems that most of the expansive dialogue occurred when students moved towards agreement, first with five as two more than three and then with seven as two more than five, as they entertained with each other a shared meaning of two more than and checked they are thinking the same. The contractive terms suggested that students were concurring and pronouncing how they now shared the relational meaning. Such analysis suggests that young students are capable of using language to share multiple ideas and arrive at a common understanding. The focus on SFL provided an alternative way to understand the symmetrical scaffolding that is taking place.

Further studies of young students' dialogue within shared group work are needed to establish this premise. In addition, the role of the researcher in instigating the students' dialogue is relevant and raises the question, how can a teacher instigate such dialogue in a classroom? What are the prompts and probes that encourage young students to use both expansive and contractive terms in productive ways? We note that the adaptation of Martin and White's engagement framework suggested a more limited choice of engagement language by these young students. Further research is needed to determine if extended use of prompts and probes modelled by teachers would develop the students' language choices to include more engagement terms. Also of note is the use of gestures, such as the nod of a head, a quizzical look, or directing attention by pointing and modelling using representations. Whilst SFL and the engagement framework focus on language and use of terms, the use of gestures seemed an intrinsic part of the dialogue and further work is needed to explore their role in expansive and contractive ways.

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