Describing the nature and effect of teacher interactions with students during seat work on challenging tasks

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As part of a project that is examining how to support teachers in the use of challenging tasks and those teacher actions that encourage students to persist, we focused on the activities of students and teachers during seatwork. We describe the nature of teacher interactions with students, student behaviours when working on challenging tasks, and the relationships between the two. Interactions that seemed most beneficial were brief, and usually preceded by the teacher watching and listening to the students at work.

Background

The Encouraging Persistence Maintaining Challenge (EPMC) project has been investigating the ways teachers can be supported to use challenging tasks in mathematics and what teacher behaviours might encourage students to persist (Sullivan et al., 2011). We use the term *persistence* to describe student actions that include students concentrating, applying themselves, believing that success is possible, and making an effort. We describe tasks as *challenging* in that they allow for the possibility of sustained thinking, decision making, and risk taking.

Three elements considered key to helping students engage with, persist at, and learn from challenging tasks are "the ways in which the tasks are posed, the interactive support for students when engaged in the tasks and collaborative reviews of the class explorations" (Sullivan et al., 2013, p. 1). The research team has previously reported on a proposed structure of the lesson (Sullivan et al., 2014), ways of introducing challenging tasks (Cheeseman, Clarke, Roche, & Walker, under review), and the effective use of the summary phase (Walker, 2014).

The three key elements mentioned tend to occur in one of the three phases of the lesson: Launch-Explore-Summarise (Lampert, 2001). In this paper, we examine one aspect of these key elements or lesson stages: the explore phase. Japanese teachers use the term *kikan-shido* to mean *between desk instruction*, describing that phase in the lesson when students participate in seatwork, sometimes individually or in groups, while the teacher roams around the classroom, providing support and interacting with students as necessary. The activities and function of these interactions have been documented across several countries in the secondary context (O'Keefe, Xu, Li Hua, & Clarke, 2006). O'Keefe et al. (2006) developed a list of teacher activities during kikan-shido that were common across 12 countries in 8th grade classrooms. The four principal functions for these activities were: (1) monitoring student activity; (2) guiding student activity; (3) organisation of on-task activity; and (4) social talk. For a detailed description of each function and the related activities, refer to O'Keefe, et al. (2006).

Stein, Grover, and Henningsen (1996) examined the extent to which the implementation of a task remained consistent with how it was set up and the factors that appeared to be associated with the decline of task demand, particularly when the task had high cognitive demand. Some of the reasons for the demand declining were teachers over-explaining the task, students failing to engage with the task, and teachers providing too

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little time for students to explore and think about the task.

As students work in small groups to solve problems, Yackel, Cobb, Wood, Wheatley, and Merkel (1990) asserted the importance of social interactions (between teacher and student and among students) that provide opportunities for students to explain their thinking and to understand one another's thinking.

The research questions that guided this aspect of the project were:

1. What is the nature of teacher interactions with students as they are working in pairs on challenging tasks?
2. Which teacher interactions seem to be the most productive for student work?

The Project Context and Data Collection and Analysis

In 2014, 47 teachers from Years 3 and 4 at 13 Victorian primary schools began their involvement in the project. The data reported in this paper were collected from two Year 3 classrooms in an independent girls' school. Each class consisted of 16 students. The teachers in these classrooms were each videotaped teaching three of the ten lessons provided by the EPMC project during a professional learning day. The content for the ten lessons was addition and subtraction, with an emphasis on mental strategies. As well as a single camera on a large tripod set up to capture the teacher's movement and words, four small cameras were placed on tables to capture pairs of students as they attempted to solve tasks. The five cameras enabled us to film the teacher interactions with eight students in each classroom. The students completed a pre- and post- online test on similar content to the lessons. The teachers were interviewed after each lesson about their perceptions of the students' engagement and learning, and these interviews were transcribed. Work samples were collected from all students in every lesson.

Each lesson consisted of a main task, possible prompts, and a consolidating task. An important feature of the lesson documentation was the inclusion of *enabling prompts* for students who have difficulty making a start on the main task and *extending prompts* for students who finish quickly. The intention was that the student who succeeds on the enabling prompt(s) could then proceed with the original task (see Sullivan, 2011). During the professional learning day, the teachers were introduced to the idea that a lesson may have three phases: Launch, Explore, and Summary phases. The Explore phase was suggested as the time when the teacher would roam around, observe students, and ask them to explain their strategies. During this time, the teachers were encouraged not to tell students how to solve the problem, but rather to provide enabling or extending prompts as required, to select students for sharing at the summary phase, and to allow students time to struggle with the task and not to intervene too quickly. One helpful idea we have used throughout the many iterations of this project is the *zone of confusion*. Teachers were encouraged to discuss with their students the notion that for genuine learning to occur, it is likely that at some stage they will be in this zone of confusion. Teachers reported that students responded very well to this notion.

For brevity, only one of the three lessons (for each teacher that was observed) will be discussed. This lesson was called *Finding ways to add in your head* and the main task was: Work out how to add 298 + 35 in your head. What advice would you give someone on how to work out answers to questions like this in your head? The enabling prompts were:

- Work out the answer to 28 + 7 in your head.
- Work out the answer to 98 + 7 in your head.
- Work out the answer to 198 + 7 in your head.

The extending prompts were:

- Work out how to add 98 + 97 + 67 in your head.
- Work out how to add 295 + 96 + 79 in your head.

In relation to the main task (298 + 35), Fuson et al. (1997) provided a very detailed analysis of students' methods in multi-digit addition and subtraction calculations, grouping them into two primary classes (*decompose tens and ones*, and *begin with one number* methods), as well as a third category of mixed strategies. In discussions of the task at the professional learning day, we anticipated the following strategies, and used the names given in parentheses:

- (Change both numbers) (298 + 2) + (35-2) = 300 +33 = 333
- (Overshoot) 300 + 35 – 2 = 333
- (Jump) 298 + 10 + 20 + 3 = 333
- (Split) 200 + (90 + 30) + (8 + 5) = 333
- (Other partitioning) e.g., 290 + 35 + 8 = 333

Interestingly, using Fuson et al.'s categories, the fourth strategy involves decomposing, the third involves beginning with one number, and the other three are mixed strategies.

The consolidating task consisted of a worksheet of four additions (each a 3-digit plus a 2-digit number), with the request to show in writing how they worked it out. No student was given the consolidating task in the lessons we observed.

All conversations in which the teacher participated during kikan-shido were transcribed, and two coders independently classified the teachers' actions, using the 16 categories of O'Keefe et al. (2006). Where the coders disagreed, discussion eventually yielded agreement. The videos of the pairs of students were observed and three that demonstrated a range of success on the task were transcribed for further analysis.

Results

We now describe three aspects of the data: the teacher activities and their frequency during kikan-shido; descriptions of some students' strategies and behaviours during seat work; and pre- and post-test results on an item of similar content to that of the lesson.

Teacher Activities During Kikan-shido

Drawing upon O'Keefe's four principal functions during kikan-shido and their related teacher activities, Table 1 shows the frequency of these activities in each of the two teachers' lessons (lessons A and B) and the time spent on kikan-shido and the proportion of the lesson spent on kikan-shido.

Not surprisingly, there are similarities and differences in the number of occurrences of each activity between the two lessons. Given the lessons were being recorded for the purposes of the project and were at Year 3 level (not Year 8), we were not surprised that there was no time spent monitoring homework completion or arranging the room. In neither lesson did the teacher need to *re-direct a student* who was perceived to be not paying attention. In both lessons, all students appeared to maintain engagement with the task. It was interesting to note that in these lessons neither teacher chose to *Give advice at the board* during kikan-shido. This was the case in all of the six lessons we observed.

Table 1
The Frequency of Kikan-shido Activities Across Two Lessons

		Lesson A 20 mins (40%)	Lesson B 17 mins (30%)
Monitoring	Selecting work for sharing	2	0
	Monitoring progress	15	7
	Questioning student	10	2
	Monitoring homework completion	0	0
Guiding	Encouraging student	12	7
	Giving instruction/advice at desk	15	9
	Guiding through questioning	2	4
	Re-directing student	0	0
	Answering a question	12	5
	Giving advice at board	0	0
	Guiding whole class	0	4
Organisatio-nal	Handout materials	0	0
	Collect materials	2	0
	Arranging room	0	0
	School related	1	0
Social talk	Non-school related	3	1

In lessons A and B, the teachers made 42 and 35 visits, respectively, to pairs of students at tables and on 10 and 5 occasions, respectively, the teachers looked and listened to students working on the task and left without speaking to them (one type of *monitoring progress*).

For our analysis, we chose to code the teachers' action of providing an enabling or extending prompt to a student or pair of students as *Giving instruction/advice at desk*. In both lessons, all students received one or other of the prompts during kikan-shido.

It is clear that while the teachers spent similar amounts of total time on kikan-shido, Lesson A had a much greater frequency of activities generally, and of *monitoring progress*, *questioning students*, and *answering questions*, in particular.

Student Behaviours During Seatwork

The students were sent to their seats to write their solution strategies for 298+35. Prior to this, they had had quiet, individual time on the floor to come to a solution without pencil and paper. At the request of the researchers, each pair of students was given one A3 page with the main task, so that they might share their strategies aloud. The eight students in each class filmed during seatwork were spread across the room with the intention of varying which students were observed over the three lessons that were videotaped.

We now provide some examples of student strategies and teacher interventions. Due to space constraints, only three pairs of students will be discussed. In each case, the student behaviours prior to a teacher's interaction (and its code), including the teacher action of providing a prompt (coded as *giving instruction*), and the subsequent student actions as a result, are described. We now describe the three events, and then reflect on them.

Event 1. Molly and Gene wrote two methods for solving 298+35 after first checking the correctness of their mental solution by using the conventional vertical written algorithm (described as *algorithm* from now on). Molly used a *jump* strategy and wrote: You could do 298+30 which equals 328, then you add 5 which equals 333. Gene wrote: You could work systematically so 298+10=308; 308+20=328; 328+2=330; 330+3=333.

At 9 minutes into seatwork, the teacher asked them to describe their solutions and then left them to think about whether there was a more efficient way. This interaction was coded as *questioning student* and lasted 70 seconds. At 13 minutes, Gene (using the strategy of *changing both numbers*) said, "You could go plus 2 is 300. Let's do it an easy way. Take the five apart into 2 and 3". She wrote: Take the five apart into two and three and then go 298+2 = 300, then add 30 equals 330, then 330 + 3 = 333.

At 16 minutes, the teacher approached and asked them to explain their most efficient strategy and then gave them the extending prompts. This interaction was coded as *questioning student* and *giving instruction*. Molly read the first one aloud ("Work out how to add 98+97+67 in your head"). They thought silently for 89 seconds. Gene said, "I haven't got the answer but if you have, what is it?" Molly answered, "257". Gene used the algorithm to check and got 262. Seatwork ended at this point.

Event 2. Sue and Nell began by discussing possible strategies for adding 298 and 35. Nell explained her strategy (*other partitioning*) and wrote: First I had 298 and then I took away the 8 and added the 35 from the number. I added 8 and got 333. Sue was unable to come up with any solution strategy. She suggested, "Counting on the ones in your head and then adding the tens." She also indicated the possibility of using an empty number line, but Nell wondered how this would be possible in your head. Sue suggested that the algorithm would also be hard in your head and that counting-on by ones "would take ages."

At 9 minutes, the teacher approached and asked them if they were ready for something "tricky". The girls enthusiastically said, "Yes." The teacher gave each girl a copy of the extending prompts, without first reading their solutions or asking them to share what they had written on the main task. Both girls were visibly perplexed by the new tasks. Sue said, "Okay, this is a bit harder than I thought it would be. … I'm in the zone of confusion." Nell said:

> How do you work this out? … I can imagine inside my head there's a big box and there's no doors and I'm trying to find my way out … I can just see it. Me in a box and I'm trapped … it's like, help.

At around 13 minutes, Sue showed her paper to the camera, which demonstrated she had written two incorrect answers. At 16 minutes, the teacher asked them to "tell me what you did for 98+97+67." Nell responded by describing a strategy that adds the numbers left to right in this way: "98+2=100; that leaves 95; 95+5=100; that leaves 62." At this point (*before* Nell added the 100+100+62 that she had created), the teacher asked Nell to describe the steps again. During Nell's responses, the teacher asked eight clarifying questions, gave one piece of advice and made four affirming statements. This was coded as *guiding through questioning*. In the second iteration of Nell's explanation, she came to the conclusion that 64 remained on the last step, hence leading to an incorrect solution. The teacher noticed this wasn't the same as Nell's first response and suggested she try again. This interaction lasted 2 minutes. Seatwork ended about one minute later.

Event 3. Zita and Sandy demonstrated solving the main task using the written algorithm and seemed unable to move beyond this solution strategy. Zita wrote the algorithm and explained the steps as: "8+5=13; so you put the 3 there, put the 1 there;

10+3 is 13; 2+1 is 3." However they both agreed this wasn't an easy method "to explain how you did it in your head." At 9 minutes, the teachers asked them to explain their strategy (*questioning student*). The teacher commented that they were using an algorithm and left them to think about how they might do it in their head. After 16 minutes, without advancing any further in their thinking, the teacher intervened and provided the enabling prompts (28+7; 98+7; 198+7) (*giving instruction*). Both girls discussed their thinking and agreed on an appropriate mental strategy (*overshoot*; 28+10=28; 28-3=35). For 3 minutes, Zita wrote (while Sandy waited): I first turn the seven into a ten. Now you know that 28+10 =38, Now you know that 7 is 3 away than 10 so now it's 38 take away 3 and that is 35. She repeated this method for the next two prompts. Seatwork ended here.

Reflection 1. Gene and Molly seemed to benefit from the teacher not providing any additional explanation on how to solve the task other than "there may be a more efficient way." This appeared to inspire the students to consider more options, leading to their discovery of one of the most efficient strategies for this addition. From the lengthy silence, it was clear that the extending prompt was challenging for the students. Neither student had trouble putting their solution strategies in writing as well as engaging with the task with minimal teacher support. However, seat work ended before they completed the extending prompts.

Reflection 2. The two students were originally clear about what it meant to solve something *in their head*, as opposed to a written method, though only Nell described a mental method to actually solve 298+35. Providing the extending prompts for both students caused a challenge as noted by their comments, and they clearly were *in the zone*. However, Sue's lack of progress on the main task meant the extending prompt was likely to be too great a challenge and this proved correct. It may be that the enabling prompt would have been more helpful for Sue to make progress. We also noticed that the teacher's desire for clarification by asking many questions interrupted Nell's thinking and made it hard for her to keep the steps of her solution in her head. It may be the teacher was struggling with making sense of Nell's strategy on the run.

Reflection 3. Zita and Sandy struggled to move beyond the written algorithm on the main task, but the provision of the enabling prompt seemed to provide just the right challenge so that Zita could access a successful mental strategy. She then proceeded to use it for all three prompts. Sandy did not solve the main task, and was left waiting as Zita solved and recorded the enabling prompt. Seatwork ended before they could go back to the main task. It may be that sharing the worksheet as a pair (as per the authors' request to the teacher) may have contributed to some students waiting for their turn to write a solution.

Student Pre and Post Test Results

The students were pre- and post-tested using an online assessment that included ten mathematics items and some survey items. The item most closely connected to the lesson *Finding Ways to Add in Your Head*, was: What is 5 + 5 + 5 + 295 + 295 +295? All six students discussed earlier were incorrect in the pre-test on this item. All but two (Sandy and Sue) were correct in the post-test. In the two classes, overall, four of the 32 students were correct on the pre-test (12.5%), increasing to 16 on the post-test (50%). This compared to an increase across all Year 3s in the project from 22.2% (*n*=752) to 47.9% (*n*=624).

Discussion

We have only reported three events of teacher and student activity during seatwork, but they support some general points and challenges that have emerged from these and other lessons we and our colleagues observed and analysed in the broader study.

In both lessons, the teachers did a number of things well. They held back from telling students how to solve the problems, selected students for sharing, and allowed students to struggle. The introductions (though not discussed here) were engaging and provided motivation for students to engage with the task, and for most students the task demand was maintained. In both classrooms, the students were familiar with the term *zone of confusion* and they understood when they were in it. In most cases, the teacher interventions were brief, and sometimes the intervention involved only watching and listening. Both teachers commented in a pre-interview that their students had had not much experience writing down their thinking and that they anticipated it might be "a challenge." However, we noticed that most students did this well. It was clear in both classrooms that the students were encouraged to share their thinking and listen respectfully. As one teacher said to the whole class, "When people were talking to each other they were looking at each other in their eyes, and they were really explaining to each other. Who thinks they learnt something from their partner?"

During the project's professional learning day the project team had encouraged teachers to allow students time to work on the task, first by themselves, then in pairs or groups. We noticed that even in pair work, during genuine struggle the students chose to think quietly by themselves. That is, without being prompted by the teacher, the students naturally took that silent time to think through the task by themselves first.

We also noticed some challenges for the teachers and students. One challenge was how to help students move beyond the written algorithm in attempting to solve tasks like these. While most students seemed to have no trouble differentiating between a solution strategy obtained mentally and a written method, some students initially struggled with deriving a mental strategy. It seemed in one instance at least, that providing a task with smaller numbers (the enabling prompt) was enough to help students make this transition. While the use of enabling prompts assisted student thinking in the lessons described, seatwork ended before there was time to revisit the main task. On some occasions we noticed that the decision to give an extending prompt without first checking students' success or understanding of the main task seemed unjustified and unhelpful for the students' progress.

Sometimes we noticed that making sense of a student's strategy and attending to the mathematics in what they were saying was difficult. Successful improvisation (Borko & Livingston, 1989) is more likely when the teacher has taught the content before and can anticipate students' responses more easily. This lesson and its structure were new for these teachers. We noticed sometimes that extended teacher questioning (coded as *guiding through questioning*) interrupted the student's flow of thinking, and added unnecessarily to their working memory. It seemed that the most productive teacher interactions were short, well-timed interventions and preceded by respectful watching and listening (Fennema, Carpenter & Peterson, 1989).

We were very encouraged by the two classes' post-test results on an item of similar content. We noted that some students who seemed to struggle but had some success (even if the success was not on the main task, but on the easier enabling prompt) were also successful on the post-test item. We cannot be sure of course that the learning that contributed to such improvement on this item only occurred as a result of this lesson.

In summary, we have added to the body of knowledge on kikan-shido, with our focus on Australian *primary* mathematics classrooms. However, a number of questions still remain. The desirable amount of time allocated to seatwork, the recommended proportion of students who receive prompts, and the appropriate balance between individual and pair work are all areas worthy of further research.

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