# Teacher actions for consolidating learning in the early years

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All students should have access to learning experiences that help them make sense of important mathematical concepts. This study highlights teacher actions for consolidating student learning during teacher-lead discussion in the early years. We report on a case study of a Year 1 teacher involving a lesson observation. Highlights of the lesson include intended teacher actions that supported students to focus on the learning goals; use of work samples to make concepts clearer; fostering mathematical connections; and questioning strategies for promoting cognitive activation. Teacher actions such as questioning strategies and discussion of work samples may be key for helping students to achieve mathematical learning goals.

One of NCTM's (2014) guiding principles for school mathematics is that "effective teaching engages students in meaningful learning through individual and collaborative experiences that promote their ability to make sense of mathematical ideas and reason mathematically" (p. 5). Many researchers would claim that effective teaching practices can be influenced by teacher actions. Teacher actions can include how teachers prepare for teaching; approaches for launching a lesson, how they promote student-centred learning; the types of questions they pose that guide learning; and how they help students to make mathematical connections, and develop reasoning and problem solving skills (ACARA, 2021; NCTM, 2014; Rowland et al., 2009; Smith et al., 2020; Sullivan et al., 2020b).

In our research project we aim to assist teachers to enhance the mathematical outcomes of Australian students by developing new understandings in ways mathematics is learnt by early years students' (5-8 year-olds). The project, Exploring Mathematics Sequences of Connected, Cumulative and Challenging tasks (EMC$^3$) provides teachers with sequences of lessons and new approaches to curriculum. Each lesson addresses a key mathematical concept and builds on students' mathematical learning from the previous lesson. To guide teachers' pedagogical actions, we have developed a student-centred Instructional Model for supporting teacher actions when facilitating lessons (Bobis et al., 2021). The Instruction Model extends the work of Sullivan et al., (2016) and the three phases of Launch, Explore, and Summarise. The revised framework includes an Anticipate Phase where the teacher identifies the learning goals of the lesson and considers ways the students might respond to the task; and a (Re)-Launch Phase, where the teacher can pose a further task that is the same in most respects, but different in terms of context, size of the numbers, or representation.

An outcome of the project is to report on ways teachers might use our sequences of lessons to inform their teaching and guide student learning. This paper reports on a case study of a Year 1 teacher and will inform further data collection as part of the larger project. The teacher was selected because she had been observed on several occasions throughout the year and was proficient at using the Instructional Model. Proficient teachers in the study

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were expected to follow the lesson structure of Anticipate, Launch, Explore and Summarise (Bobis et al., 2021). The research questions guiding the study were:

> What types of questions did a Year 1 teacher rely on when consolidating student learning and sharing work samples?
>
> How did a proficient Year 1 teacher rely on her teacher actions to guide her instructional decisions when discussing and sharing student work samples?

By observing teacher actions, we aim to identify how they increase opportunities for student learning and success through subsequent tasks. Findings will assist other teachers as they reflect on their actions when implementing the 10 sequences of lessons and suggestions.

Next is the review of literature and the theoretical model used to inform the study.

## Literature Review

Effective mathematics teachers establish goals to focus and guide student learning (NCTM, 2014). Others suggest teaching approaches should be student-centred (Staples & King, 2017). Another attribute of quality teaching is to provide students with tasks that support cognitive activation by encouraging students to think in greater depth about problems (NFER, 2015). Such tasks may be open-ended, having more than one solution or have multiple approaches used for solving the task (open-middle) (Sullivan et al., 2020a). Other strategies intended to support cognitive activation include questioning techniques such as asking, "What if?" or "Might there be another way?" type of questions (NFER, 2015).

Effective mathematics teachers should provide opportunities for purposeful questions that promote reasoning (NCTM, 2014), guide learning, thinking and exchanging of ideas (Staples & King, 2017) and help students to make sense of solutions (Evans & Dawson, 2017). Sahin and Kulm (2008) described factual, probing and guiding question types in their review of literature. Factual questions require little cognitive challenge and are closed question types that usually require yes/no answers; probing questions help students to clarify, justify or explain; and guiding questions can assist students when responding to questions. When posing questions teachers must consider the types of questions they ask as well as the pattern of questions they use if they are to promote students' reasoning skills (NCTM, 2014).

### *Theoretical Framework*

An adapted version of Clark and Peterson's conceptual framework (1986) was used to guide the study (Figure 1).

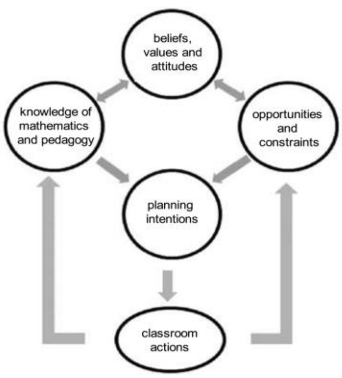


*Figure 1.* Framework adapted from Clark and Peterson (1986).

Clark and Peterson (1986) suggest teachers' classroom actions are informed by the relationship between knowledge of mathematics and pedagogy; dispositions including, beliefs, values and attitudes; opportunities and constraints they anticipate experiencing; and planning intentions. We anticipate that when teaching sequences of challenging tasks teacher actions guide their pedagogical decisions when posing questions, whilst sharing and discussing student work samples. Data analysis for the current study reports on one teacher's classroom actions when observed teaching a lesson.

## Method

A qualitative study and case study were chosen to assist with providing an in-depth description of the circumstance (Yin, 2009). The study explored how Abby (pseudonym) approached her discussion with students when she was observed teaching a geometry lesson with Year 1 students. During the year, Abby first participated in a whole day of professional development to learn how to use the project resources; she attended six planning sessions with a member of the research team; was observed teaching on six occasions; and had trialled most of the ten sequences of lessons with her students.

Abby was observed teaching the first and second lesson of a shape sequence at the end of the year. The rationale for the shape sequence was to help students when classifying, making, naming and describing two dimensional shapes (polygons). The first lesson focused on students classifying groups of polygons, explaining similarities and differences. The second lesson (reported in the results) focused on students making and learning the names and properties of polygons. Students were asked:

> If you have 6 triangles all the same, what shapes can you make using all of the triangles; draw the new shapes you have made on dot paper [isometric] and name the shapes.

The next lesson in the sequence used trapeziums to make and name shapes and introduces the term chevron [and was not taught].

Proficient teachers in the study were expected to Anticipate students' solutions prior to teaching and launch each lesson without telling students how to respond to the task. Following the launch, students were expected to independently engage and attempt the task whilst the teacher observed and monitored their work as the lesson unfolded. The next phase of the lesson was the Summarise Phase [and occurred three times during the lesson reported in this study]. In this phase, students were selected to share their work samples. The teacher led a whole class discussion, similar to the framework for orchestrating mathematically productive discussion (Smith & Stein, 2018). Questions were posed by the teacher to the student(s) sharing their work sample or the whole class, helping students to clarify or explain their strategies, thinking, reasoning and/or problem solving skills.

### *Data collection and analysis*

The launch and three Summarise Phases of the lesson were video recorded by the first author. Abby's lesson plan (including four anticipated student responses) and student work samples were collected. The lesson transcript was transcribed for coding and included the questions and student responses for each of the three Summarise Phases. The questions were coded as factual, probing, or guiding by two authors until a consensus was agreed (Table 1).

Table 1
*Sample of coding teacher questions and explanation of coding*

| Coding | Illustrative question | Explanation of coding |
|---|---|---|
| Factual | Should I call this shape a trapezium? | Yes/no answer closed question |
| Probing | Why can't I call this one a trapezium? | Asking students to justify or explain their thinking |
| Probing | Who can tell me why? | Seeking clarification |
| Guiding | What do you notice about the edges? | Prompting students to focus on the edges when answering |

Two authors partitioned the transcript into eight segments. Each segment included discussion of a key mathematical concept and/or student work sample. The segments assisted with identifying teacher actions Abby modelled during the lesson. Highlights are reported and discussed next.

## Results and Discussion

The length of each summarise phase increased throughout the lesson and the lesson took 90 minutes to complete. During the lesson, five student work samples were shared. Table 2 reports the number and type of questions Abby posed for each Summarise Phase of the lesson and number of segments within each phase.

Table 2
*Number of Summarise Phases of the lesson, segments and types of questions*

| Phase and Segments | Factual | Guiding | Probing | Total |
|---|---|---|---|---|
| Summarise 1(3 minutes)<br>1 Segment | 10 | 3 | 0 | 13 |
| Summarise 2 (8 minutes)<br>3 Segments | 20 | 4 | 21 | 45 |
| Summarise 3 (19 minutes)<br>4 Segments | 48 | 15 | 25 | 88 |
| Total | 78 (53%) | 22 (15%) | 46 (32%) | 146 (100%) |

Effective teachers use a variety of questioning types as part of their teacher actions (NCTM, 2014). The results in Table 2 show Abby relied on different question types. Half of Abby's questions were factual (closed) questions and less than a quarter were guiding questions. As the topic of shape relied on naming shapes and their properties this may be a reason more questions were closed question types as Abby posed closed questions to help students develop geometric language. One third of the questions were probing questions. Probing questions are important for helping students to clarify, justify and explain their thinking (Sahin & Kulm, 2008), assisting students to make sense of mathematical ideas and demonstrate reasoning.

Next a selection of Abby's teacher actions is reported focusing on the summarise phases.

### *Selecting work samples*

For each Summarise Phase Abby selected one to three student work samples to discuss with the whole class. The work sample was projected onto a white board. The students sat together on the floor and the students sharing their work stood next to the teacher. The first student work sample that Abby chose showed four polygons, including two quadrilaterals (Figure 2).

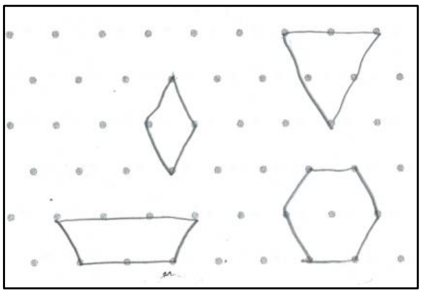

*Figure 2*. Four responses recorded on dot paper.

As a number of students had not attempted to record their solutions the work sample (Figure 2) provided an opportunity for all students to see how to use the dot paper, which they had not used previously. Arguably there are different reasons the teacher may select a student work sample first; the most commonly used strategy; an incorrect solution; misconception; or example of concrete to abstract (Smith & Stein, 2018). The first work sample Abby shared helped clarify how to record solutions and guided the students to focus on the learning goal, using triangles to make, name and record polygons. When discussing the work sample Abby also made connections to the previous lesson. A student named the first shape a diamond and Abby replied, "Yesterday we decided not to call these shapes a diamond … yes a quadrilateral."

This discussion demonstrated how Abby's classroom actions were influenced by her own mathematical content knowledge of how to name polygons.

### *Questioning strategies*

When asking students to discuss their work samples, Evans and Dawson (2017) noted that teachers usually prompt students by first posing an open-ended question such as, "How did you solve this problem?"

Abby asked the following closed questions at the beginning of each of the three summarise (S) phases:

S1: I want you to tell me out of these four shapes, which one do you think meets the problems keywords?
S2: This is a fun one isn't it?
S3: Should I call it a trapezium?

Interestingly Abby chose to ask closed questions when commencing each Summarise Phase. There may be any number of reasons Abby chose closed questions, such as wanting to help the students to re-engage with the task, providing a warmup question, or because she considered that an open question to begin with may cause students to encounter challenges and disengagement. Another conjecture might be that Abby was assessing or reviewing student understanding before moving on, helping her to think in the moment and therefore guide her follow-up questions.

### *Supporting cognitive activation*

Cognitive activation occurs when students think more deeply about facts or concepts (NFER, 2015). An important observation was how Abby used different question types to cognitively activate students as she engaged them in mathematical discourse and consolidated their learning. Segment 3 provided an example of Abby's teacher actions when demonstrating her questioning strategies for supporting cognitive activation. The students were discussing an irregular hexagon (one student named an apple core) and a regular hexagon, both constructed with six triangles.

> Abby: Hands up if you don't think it is a shape [pointing to the irregular hexagon]? (factual)
>
> Abby: Why don't you think it is a shape? (probing)

Some students thought it was not a shape because they had never seen the shape before, one that goes in and out like that.

> Abby: What name did you give this shape? (probing because there is more than one answer)
>
> Student: An irregular hexagon.
>
> Abby: Why is it an irregular hexagon? (probing).
>
> Abby: How many sides does your shape have? (factual)

The use of a factual question was followed up with probing questions demonstrating how Abby posed questions to help make the mathematical concepts clearer for the students. Abby's actions show skilful use of a factual question (typically) having a lower level of cognitive demand, followed by probing questions (typically) having a higher level of cognitive demand, encouraging students to justify and explain the properties of regular and irregular hexagons. In other words, the factual question required students to engage in the discussion by choosing a yes or no response, focus their thinking, ready for the following probing questions that supported cognitive activation.

### *Fostering mathematical connections*

Fostering mathematical connections for students was another action Abby modelled to help make concepts clearer. The focus in Segment 2 was to clarify the properties of 'real shapes.' A student named the bottom figure a candy-bar (see Figure 3).

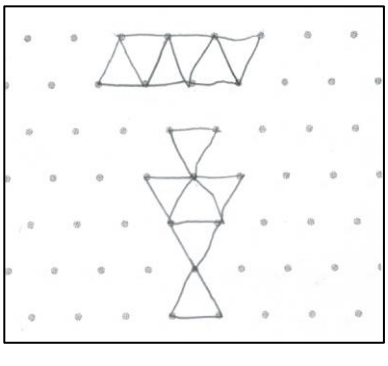

*Figure 3*. A quadrilateral and a candy bar

During this discussion Abby used 'why' and 'what' type questions such as "Why do you think it's not a shape?" and "What do you think?" Some students considered it was a shape and others disagreed, but the students were not really sure. The nature of these questions provides another example of Abby engaging students in cognitive activation. The combination of why, what and probing questions encouraged students to reason, clarify and justify their thinking about the 'candy bar' and experience a light bulb moment. In particular, Abby asked questions designed to support students to notice that the edges of the triangles did not always overlap ("What are those bits called?"), and that the corners or vertices need to overlap to make a (real) shape. Other teachers in the project also reported experiencing light bulb moments with their students when important mathematical connections were highlighted for, and by, the students (Russo et al., 2020).

In terms of the study's conceptual framework (Clark & Peterson, 1986), Abby's beliefs and values influenced her choice and ordering of work samples during the lesson. Abby valued the importance of the Anticipate Phase, particularly anticipating her student work samples prior to teaching as she considered how they might respond to the task prior to teaching. Doing so allowed Abby to increase the level of cognitive activation because she was familiar with different solutions and therefore could focus on discourse for consolidating student learning. Further evidence of Abby's beliefs could be gained from an interview after the lesson, which did not occur.

## Conclusions

During the Summarise Phase of the lesson Abby relied on a combination of factual, probing and guiding questions to make connections among important mathematics concepts/ideas and student work samples that ultimately helped to consolidate their learning. Abby modelled a well-developed understanding of the different terms used to describe the properties and names of different polygons when questioning students as part of her teacher action and knowledge of mathematics and pedagogy. Without such knowledge this would have impacted on her classroom actions especially selecting and discussing examples to make concepts clearer when guiding students to the learning goal of the lesson and sequence.

When helping students to make connections in the elementary classroom, Smith et al., (2020) state the importance of the role of the teacher for helping students "see connections between the solutions that are shared and the goals of the lesson (p.141)". Specifically, Abby was able to help students make connections with the goal of the lesson by asking students to explain their thinking related to the names and properties of the different polygons, and to make, name and describe two dimensional shapes (polygons). This lesson approach is different to that described by Smith & Stein (2018) in that our research-based teaching suggestions, Instructional Model and teacher actions support students to make connections with the mathematical goal of a sequence of lessons. Such student-centred pedagogical approaches aim at consolidating student learning in greater depth.

Further lesson observations and assessment of student knowledge prior to and after a sequence will assist with extending understanding of the strengths and weaknesses of how students learn during a sequence and as a consequence of teacher actions. We note the limitations of reporting on one case study and a single lesson but anticipate the findings from this small study will help teachers to reflect on their questioning approach for deepening the learning during the Summarise Phase of lessons.

In terms of more general research directions suggested by this study, it is notable that Abby used different question types in complementary ways. In particular, we discussed how a factual question was often followed by a probing question. We commented that the purpose of asking the factual question appeared to be to engage students, whilst the follow-up probing question served to activate cognition. Future research could consider whether this strategy was idiosyncratic to Abby, particular to a lesson exploring properties of shapes, or whether using the different question types in this manner characterises effective teachers more generally when teaching primary mathematics.

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