Improving the Effectiveness of the Whole Class Discussion in the Summary Phase of Mathematics Lessons

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The following is a report of aspects of a project that is exploring the implementation of mathematically challenging tasks and ways of supporting teachers to facilitate effective lessons. Teacher participants indicate that the three-part lesson structure proposed for implementation is valuable. However, they continue to describe the summary phase as complex. The data presented below suggest that repeated opportunities for students to voice their strategies in a cumulative approach may lead to a more purposeful whole-class discussion during the summary phase.

Much has been written about the importance of an effective plenary discussion to conclude a mathematics lesson, but many teachers continue to find the actual enactment of this phase challenging. It is assumed that teachers can successfully conclude their lessons and within that conclusion, summarise the learning that has occurred, provide a final synthesis of mathematical ideas, facilitate a whole class discussion and praise efforts from the lesson. However, current research and observations through the Encouraging Persistence and Maintaining Challenge (EPMC)[i] project would suggest that there is a need for more explicit attention to the orchestration of an effective summary phase.

The complexity lies in planning for a worthwhile discussion which will "simultaneously honour both student thinking and a mathematical agenda" (Stein, Engle, Smith, & Hughes, 2008). A rich, whole class discussion serves a number of important purposes: to foster a community of learners; to build student confidence; to develop justifying, thinking and reasoning skills; and to improve the mathematical understanding of students involved. The focus of this research is to explore ways in which teachers can effectively draw on students' problem solving experiences and insights to summarise and consolidate mathematics learning. This paper reports on teacher feedback gathered throughout a research project where teachers were asked to facilitate a summary phase at the end of their lessons in which student ideas are used to clarify and exemplify cognitively complex mathematical tasks.

Using Challenging Tasks

While the benefits of using challenging tasks in the classroom are wide reaching, in the context of an effective summary phase, they are critical. For worthwhile discussion to occur, the project argues that students benefit from being offered a genuinely thought-provoking problem in which they devise their own strategies and explore new ways of thinking. The task will ideally offer a range of possible solutions, allow for different levels of mathematical proficiency, and potentially be presented in a way to the students that is unfamiliar. Through promoting the 'puzzling', the intent is that students will have something worthwhile to discuss. Working on a challenging task creates opportunities for purposeful whole class discussions.

Challenging tasks as described by the project team are those that allow students opportunities to:

- plan their approach, especially sequencing more than one step;
- process multiple pieces of information, with an expectation that they make connections between those pieces, and see concepts in new ways;
- engage with important mathematical ideas;
- choose their own strategies, goals and levels of accessing the task;
- spend time on the task;
- explain their strategies and justify their thinking to the teacher and other students; and
- extend their knowledge and thinking in new ways. (Sullivan, Aulert, Lehmann, Hislop, Shepherd, & Stubbs 2013, p.619)

One of the critical features that has been acknowledged to be evident in classrooms having success with these challenging tasks are the classrooms where a positive classroom culture has been fostered, and one in which, student voices are valued in the learning process. As Sullivan et al. (2013) state "the key elements seem to be the way the tasks are posed, the interactive support for students when engaged in the tasks, collaborative reviews of class explorations and assessment against criteria" (p.1). In referring to the collaborative reviews of class explorations, it is agreed that developing a regular routine where students are expected to explain their strategies and justify their thinking to the teacher and their peers is part of the challenge of these challenging tasks.

The research questions that guided the data collection presented in the following were "What actions can teachers take to create the potential for the summary phase of lessons to be more effective? How do teachers use students' problem solving strategies during the summary phase to review the mathematics of the lesson?"

The Project Context and Research Framework

The findings reported in this paper relate to data collected from 35 teachers of Years 5 & 6 in 16 Victorian primary schools. Data were collected in a number of ways. The teachers were surveyed before and after their involvement in the lesson trials. Twenty teachers also completed one-page lesson reports, including short-answer questions completed immediately after teaching each lesson. Finally, the teachers were invited to provide verbal feedback at the professional learning days. Segments of observed lesson were audio-recorded and transcribed, as well as recorded hand-written observational notes and students' worksheets being collected.

At the beginning of the research, the project team provided teachers with a series of lessons in each of which a challenging mathematical idea was developed. Each lesson consisted of a set lesson structure being: Launch, Explore, and Summary.

Lappan and Phillips (2009) describe the summary phase:

The final phase of the instructional model is the summary. This is the most important and, perhaps, the hardest phase to do well. Here the students and the teacher work together to make the mathematics of the problem more explicit, to generalize certain situations, to abstract useful mathematical ideas, processes, and concepts, to make connections, and to foreshadow mathematics that is yet to be studied.

Sullivan (2009) goes as far as to articulate the two parts essential in the lesson review. He describes the first part as being contributions from students where strategies and

approaches are offered to the whole class. Cheeseman (2009) describes the purpose of this as: gathering evidence; sharing common discoveries; celebrating learning; learning from each other; encouraging students to reflect on what they had learned; and building positive attitudes. The second part focuses on the teacher's role in drawing together the mathematical learning of the lesson, making links explicit and extending understanding. The advice provided by the project team regarding the summary phase suggested that teachers should select students who represent a range of approaches to explain their solution strategy and other insights to the class; assist students with an efficient way of presenting their work to the class; and invite questions from other students and in doing so, ask them to compare the student methods. Smith and Stein (2011) argue it is possible that, when one student presents a solution, other students can be invited to describe what that student has done.

While it was explained to project teachers that this three-step sequence can happen a number of times within a lesson, the format tended to be implemented in a linear way rather than circular, where the sequence looped back to be repeated and revisited. This meant that there was typically only one 'launch' at the beginning of the lesson, one set time for students to 'explore' the challenging task and one 'summary' at the end of the lesson to discuss ideas. One of the realisations was that a more circular approach was not used by many project teachers to allow students to verbalise and clarify their thoughts in an ongoing manner throughout the lesson. It may be the case that teachers saw the three part structure as a prescription.

During the professional development days with the teachers, various members of the project team modelled the lesson structure being advocated in order to provide a prototype of actions for the implementation of the challenging tasks. The examples were explicit with regard to launching straight into the task without pre-teaching or demonstration. Plenty of time was allowed for the teachers to work through the tasks. Opportunities were given for teachers to discuss their working and share their thinking, to ask questions, seek clarification, and to refine and assess their solutions during the exploring phase. Then the summary was presented, by reflecting on the learning that happened and discussing the variety of responses. One of the issues of interest was whether teachers gained sufficient clarity with regard to scaffolding an effective summary phase from these workshops.

These two concerns, being the prescriptive approach to the lesson structure and the preparation of teachers for the complexities of the summary phase, were evident upon the commencement of classroom observations. In the first part of the research project, I visited four Year 5 & 6 classrooms. Whilst the teachers facilitated the challenging tasks well and the students were engaged by their learning, what I observed during various observations was a smorgasbord offering of ideas and strategies. An opportunity to improve the ending of the lesson, beyond the 'show and tell' model to facilitate a more carefully constructed learning moment for the class was evident.

Results

Three aspects of the results are presented: the teachers' responses initially; the emergence of the summarising on the run strategy; and subsequent data collection from the teachers.

Teacher Responses after Phase 1 Trial

Following the first round of classroom trials, the project team gathered feedback from the teachers about their actions in implementing the challenging tasks. With regard to the summary phase, teacher responses indicated that they were becoming more aware of the complexities within this part of the lesson. As Cheeseman (2009) said "I think we must be careful in referring to the end of the mathematics lesson as a 'sharing time' even in casual conversation as the phrase clearly underplays the complexity and importance of this part of the session" (p.5). When asked what they thought the main purpose of the summary phase was, teachers responded on a survey with comments such as:

- to draw out the key mathematical understandings; strengthen understandings

- allow a variety of students to share ideas and to spark ideas in others

- give children the opportunity to share their successes and to challenge each other

- to promote a culture where the answer is not the end, the working out is equally important

- to allow the teacher an opportunity to assess properly

- for the students to be reflective concerning their attempts at the learning.

While teachers were acknowledging the wide ranging challenges of a successful end of lesson, generally teachers wanted more guidance, explicit scaffolding strategies, or even things to say during the summary phase as part of their professional development. As there are many instances where teachers need to be flexible and bring the summary together based on the evidence of learning, providing this type of support for teachers is difficult, as mentioned by this teacher when asked if there was 'anything that could be added to or taken out of the lesson suggestions':

> I wouldn't take anything out but I would maybe add some suggestions for things to say during the summary phase although I understand this is somewhat dependent on the student responses.

One of the key elements in facilitating a highly effective summary phase is the actions and preparations that take place prior to the lesson commencing, and during the exploration phase of the lesson. In relation to Smith and Stein's (2011) recommended practices of anticipating and monitoring, it is in these practices that teachers 'actively envision' how students might approach the task and pay close attention to what students are doing as they complete the task. It is these expectations, conversations and observations that can assist in choosing students to focus on during the whole-class discussion (Lampert, 2011; Stein et al., 2008). This led to the emergence of a strategy that may encourage teachers to engage in more purposeful monitoring.

'Summarising on the Run' Strategy

Throughout my classroom observations and subsequent debriefs, I investigated the actions that teachers took to support the summary of the lesson. I was interested to see how they considered and planned for the conclusion. My initial question asked: "How did you go about trying to plan for the summary part of the lesson? What did you actively do today or when you were preparing for today?" One teacher explained:

> I thought about what strategies I would be looking out for, so I went back to my notes from when I had worked it out myself when we had the [teacher professional development] day … then also looked at the possible strategies from the project book.

This was a fairly typical response from the teachers I spoke with. It showed some evidence of forward planning and considerations for the possible strategies that might evolve from the challenging task.

One teacher, however, described a very different strategy. When I asked: "How have you gone about actively planning for and facilitating the summary part of the lesson?", her response was:

> Well at the moment we sort of don't … we do it on the run! (Ms A) and I team teach together, and what we did with the first task is that we could see that there were some kids that were bogged down, and there were others that were really getting it. So (Ms A) suggested that we stop in the middle and go into some summarising because it'll give some kids some more ideas. And by this stage we were also seeing that they weren't using different methods. So we thought that we needed to stop and show some different methods and talk about the task. So in the next lesson, we did it the same. We summarised mid lesson & again at the end. I really like 'summarising' in the middle. The kids might learn something from it, but if it's only at the end, they don't get a chance to have a go at it.

This led me to the idea that repeated, informal class discussions could enable the students, as well as the teacher, 'to pay close attention to what students are doing as they complete the task'. This small action could trigger more purposeful monitoring, and therefore benefit the final summary at the conclusion of the lesson. For the purposes of this project, I called this strategy 'summarising on the run'.

Many teachers are well versed in the need to 'plan on the run' in order to cater for the students' ever changing needs, learning interests, and successes. We even talk about the need to 'plan on the run' in the middle of a lesson, when a student response takes the lesson in an unexpected direction. However, in order to ensure the lesson is still a successful one, teachers must be mindful to engage in discussions with students that will enhance their current understandings.

In taking the term 'on the run' to imply flexibility and spontaneity, a strategy that numerous teacher participants described was to create opportunities for students to share part-way through the lesson, instead of holding back until the end, 'summarising on the run'. While it allowed students to share their partially constructed solutions and reflect on their strategies so far, it also gave teachers an insight into where the task was going mathematically.

In wanting to investigate the effectiveness of this strategy, eight project teachers were asked to try it out. My suggestion was:

> ... instead of leaving student sharing until the end of the lesson, I'd like you to think about how 'summarising on the run' could enhance the mathematics being learnt. You could stop the students a few times during your lesson or just once, but in doing so, the purpose is to enhance the learning, but without explicitly giving it all away.

I also asked the teachers to consider these two points:
- That key mathematical ideas and relationships, as represented in the task statement, are explicitly discussed. But no solutions are given away fully!
- That common language is developed to describe contextual features, mathematical ideas and relationships, and any other vocabulary central to the task statement that might be confusing or unfamiliar to students is clarified.

Teachers were asked to keep informal reflective notes to gather feedback. Further classroom observation visits were also arranged. My intent was to see if this purposeful 'summarising on the run' would enhance the summary phase.

After only one week of trialling the 'summarising on the run' strategy, two teachers emailed me keen to share their successes. The first explained:

> Stopping the lesson around the 15 minute mark and allowing selected students to do a mini share of 'this is what I'm doing', encouraged other students to rethink or take another direction.

The other teacher said:

> I tried this approach using a EPMC Challenging Task with a group of grade 4 students. I must say it worked well. It meant I didn't need to give out as many enabling prompts as students began thinking about and trying ideas suggested by their peers.

In both cases, the benefits the teachers are experiencing relate to students sharing their mathematical ideas and challenging others to reflect on their thinking. Even the students who are not explaining and justifying their solutions are actively processing their current thoughts and deciding whether to continue or to try something different, as inspired by their peers. This scenario also describes a classroom space where all the students are involved in the learning process, working and developing together. The result that less 'enabling prompts' (prompts for students experiencing difficulty) were used is an interesting point for the project team to continue to explore.

These encouraging responses continued from the eight teachers trialling the 'summarising on the run' strategy. All the feedback was positive in involving students to talk about their mathematical thinking. The benefits included:

- allowing more students to access the challenging task;
- requiring less enabling prompts;
- encouraging students to rethink and clarify their ideas;
- opportunities to revisit important mathematical language; and
- higher levels of engagement as all students were experiencing success.

Another benefit of this strategy is being able to combat teachers' tendency to over explain the tasks. The 'summarising on the run' strategy allows teachers to feel comfortable that they can come back and revisit the important ideas shortly, not having to leave it until the end of the lesson. In fact, teachers can feel secure in 'summarising on the run' in a progressive manner and building up ideas as the class works through the task, rather than trying to explain it all upfront.

Survey Results after Phase 2

After the second phase of classroom trials, project teachers were again asked to reflect on the success of the tasks and their change in practice. In reference to the summary phase, the questions asked "How has your summary phase changed from the start of the project to now? Can you describe what actions you've taken in the lesson to enable that change?" While there were many very positive changes to the way teachers constructed the conclusion of their lessons, the overwhelming trend was 'less teacher talk'. Here is how teachers described this change:

> I now allow more time in my lesson planning for the students to summarise, to allow students to learn from each other, to share their solutions and discuss their learning. Students who were reluctant to share strategies at the beginning now love to!

> Instead of the obligatory 5 minutes reflection using a stem (usually chosen by the teacher) the summary phase now consists of ongoing reflection periods which are led by the students, for the students. The summaries can be undertaken repeatedly and are often filled with new learning.

Before the project I did allow for some sharing but not as much time as I do now. I've realised how important and effective it can really be.

Technology also played a significant part in enabling the summary phase to run smoothly and effectively. Teachers experimented with ways to display written work for discussion and analysis without requiring students to laboriously write their solutions out on the whiteboard. This is what teachers said about the role of such technology:

Using the document camera/ visualiser has been instrumental in supporting students to talk to the strategies and encourage students to respond and build on the conversation. The summary phase is definitely becoming more meaningful and purposeful rather than just a show and tell.

The big difference that really helped my summary phase was taking photos of the students' work and putting them straight onto the IWB. This enabled students to articulate their work without having to write it up again ... It really engaged the students as they had pride in presenting and talking about their mathematical achievements.

This is not to say that teachers were no longer experiencing challenges with facilitating the summary phase. The sticking points continue to be around teachers talking too much and controlling the discussion, and students who do not want to listen to the ideas of others and lose interest. Data collected by teachers in both Phase 1 and Phase 2 indicate however, that this is not a significant trend for the research schools. In fact the teachers report that most students do generally listen to the explanations of others as presented in Table 1.

Table 1
Responses of Teachers to Prompts about Student Attentiveness to Responses of other Students

	SD	D	U	A	SA	Total responses	Mean
PHASE 1							
My students generally listen carefully to the explanations of other students	0	2	2	23	7	34	4.03
PHASE 2							
My students generally listen carefully to the explanations of other students	0	1	3	19	8	31	4.35

Conclusion

The project, from which these results are a part, is exploring whether students learn mathematics through engaging with challenging tasks. In terms of this paper, it would seem that students are better able to engage with, analyse, justify and explain their thinking and learning in these challenging tasks when they are given repeated opportunity to do that within the lesson structure.

Results and observations reveal that teachers need to anticipate how students are going to approach the task; purposefully monitor their thinking as they work through the mathematics and draw the learning to a close through a well-constructed summary. One key element to this process is incorporating the 'summarising on the run' strategy, allowing

the purposeful monitoring to involve student voice and thereby enabling ideas to be shared and progressively developed, as well as the teacher observing where the lesson is heading. The 'summarising on the run' strategy is a seemingly simple action, which can improve the final summary phase of the lesson.

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