"The Task is Not the Challenge": Changing Teachers' Practices to Support Student Struggle in Mathematics

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In this paper, we report on changes to teachers' knowledge and practices as a result of their participation in a professional learning initiative focused on cognitively challenging tasks and the pedagogies for enhancing student reasoning as such tasks unfold. Data from 239 primary teachers who responded to an online pre- and post-professional learning questionnaire revealed significant changes in their commitment to challenging tasks and their allowance of student struggle. Classroom observations and follow-up semi-structured interviews with two teachers are used to shed light on what these reported shifts in teacher practices looked like in the classroom.

Introduction and Background Literature

Mathematical tasks are central to the teaching and learning of mathematics. As so eloquently phrased by Anthony and Walshaw (2007, p. 3), "it is through tasks, more than in any other way, that opportunities to learn are made available to the students" because it is through tasks, that students' attentions are directed to important mathematical ideas (Stein, Grover & Henningsen, 1996) and cognitive processes can be activated. However, research tells us that certain types of tasks are more effective at activating higher levels of reasoning in students than others. The National Council of Teachers of Mathematics (2014) noted that:

> …student learning is greatest in classrooms where the tasks consistently encourage high-level student thinking and reasoning and least in classrooms where the tasks are routinely procedural in nature. (p.17)

Despite converging evidence indicating that the quality of learning is greatest when students are exposed to cognitively demanding tasks (Boaler & Staples, 2008; Stein & Lane, 1996), teachers are reluctant to incorporate such tasks into their teaching (Hiebert, Gallimore, Garnier, Bogard-Givvin, Hollingsworth, Jacobs et al., 2003). Moreover, even when teachers are supplied with challenging tasks, there is no guarantee that they will be implemented with the intended level of challenge (Arbaugh, Lannin, Jones, & Park-Rogers, 2006). Several reasons have been proposed for the limited uptake of challenging tasks, including teacher mathematical-task knowledge (Chapman, 2013). Such knowledge includes teachers' understandings of the benefits of challenging tasks, an awareness of the merits of student struggle, and a willingness to tolerate student struggle.

Challenging Tasks and Student Struggle in Mathematics

It is clear that not only is there a need for teachers to incorporate mathematical tasks that are structured to be "truly problematic for students" (Stein et al., 1996, p. 456), but that they also have the awareness, pedagogy and disposition for sustaining a high degree of cognitive activation throughout student engagement with such tasks. A teacher's capacity to maintain high levels of cognitive demand implies that they are able to tolerate students struggling without resorting to telling them what to do or simplifying the task (Stein et al, 1996; Wilkie, 2016).

Struggle involves some confusion while students are attempting to resolve a problem where the solution strategy and/or answer are not already known (Hiebert & Grouws, 2007). In an observation study involving six different US middle school mathematics teachers,

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Wasrshauer (2015) found that teacher responses to student struggles were key in sustaining higher levels of cognitive activation and student willingness to persist. Such responses required a high degree of teacher mathematical-task knowledge to enable them to constantly judge the level of challenge with the nature and degree of support different students needed.

Study Context and Conceptual Framework

The development of teacher mathematical-task knowledge in conjunction with their capacity to effectively enact such knowledge in the classroom was a focus of a New South Wales [NSW] Department of Education professional learning initiative – Building Numeracy Leadership [BNL]. First implemented in 2017 for teachers in *Early Action for Success* [EAfS] schools, BNL formed part of the Department's strategy for implementing the State Literacy and Numeracy Plan (2017-2020). BNL was implemented again in 2018, the year in which the current study took place. Its purpose is "to extend participants' knowledge and capabilities to enhance the numeracy outcomes of students in *Early Action for Success* schools" (BNL expression of interest, 2018).

EAfS commenced in 2012 with 50 schools. It expanded in 2015 to include 310 schools based on the Family Occupation and Education Index (FOEI) – a school measure of socio-economic status. It expanded in 2017/18 to include 555 schools, some of which were self-funded and chose to participate in EAfS. All EAfS schools were allocated an instructional leader (IL) for three years (2017-2019). ILs were allocated based on student enrolment numbers with allocations ranging between 0.2 (one day per week) to two full-time ILs. ILs have responsibilities for supporting literacy and numeracy in the first three years of school. In 2018, ILs were employed by school principals. Prior to 2017, mathematics and numeracy were generally not key foci of the schools involved in EAfS despite the majority of ILs employed to develop both literacy and numeracy. BNL was developed and offered to EAfS schools to fill this gap and help develop mathematics and numeracy.

BNL aims to enable transformative change in teachers through its PL opportunities. It not only intends to change teacher knowledge and practices but to change participants' identities as teachers of mathematics (Bobis, 2019). Such transformations have positive implications for how teachers position their students for learning and doing mathematics. Its major theoretical underpinnings stem from social constructivism, educational psychology and variation theory but it also draws upon a range of other epistemologies according to the research base relevant to the aspect of mathematics teaching and learning in question.

The conceptual framework guiding BNL implementation and the design of this study's data collection and analysis was informed by Clark and Peterson's (1986) model of teacher thought and action of instructional planning. The model was adapted to match the theories and research base underpinning BNL, and represents bi-directional relationships between teachers' thoughts and actions as they are influenced by the opportunities and constraints afforded by their participation in BNL. Accordingly, it was anticipated that teachers would be more willing to modify their instructional practices to increase their focus on developing students' higher order thinking processes and include appropriately challenging tasks if they were provided with relevant knowledge and classroom level support to enact those practices via BNL. The components of the model that refer to teacher knowledge of pedagogy and classroom actions are particularly relevant to the study reported here.

In this paper, we report on changes to primary teachers' mathematical-task knowledge and the associated instructional practices as a result of their participation in BNL. We address the question: "How did teachers' knowledge and practices change as a result of their participation in professional learning (PL) that focused on challenging tasks and the pedagogies for enhancing student reasoning as such tasks unfold?"

Methodology

Quantitative and qualitative methodology using mixed-method data sources including a questionnaire, interviews and classroom observations were used in the study.

Participants

Study participants included 563 teachers of K-6 (5-12 years of age) students and their Instructional Leaders from 110 school teams across NSW who participated in BNL professional learning. Participants were invited to complete an online questionnaire prior to and at the conclusion of the PL. At Time 1, 360 participants (90.3% female) and at the final PL session (Time 2), 331 participants (90.6% female) completed the same questionnaire. A unique identification code created at Time 1 was used to match participant responses at Time 1 with their responses at Time 2. The responses of 239 teachers could be matched for both times. Time 2 demographic data indicated that 16.4% of participants had five or less years teaching experience, 37.1% had up to 15 years and 46.5% had more than 15 years teaching experience. The high proportion of participants with over 15 years of experience was likely a result of the large number of teacher-leaders (instructional leaders/assistant principals/principals) attending the PL. While BNL targeted the early years of primary school, teachers of K-6 were involved.

Respondents to the questionnaire were asked to provide their contact details only if they wished to be included in an interview and classroom observation follow-up phase. A total of 25 interviews were conducted, including 15 classroom teachers, five instructional leaders and five principals from six different primary schools from across NSW.

Data Gathering: Instruments and Procedure

Questionnaire. An online questionnaire was used to collect data on specific aspects of teachers' mathematical knowledge, conceptions and practices for teaching mathematics prior to and at the conclusion of the PL. Part A of the questionnaire collected biographical information reported earlier. Part B was adapted from the Ross, McDougall, Hogaboam-Gray, and LeSage (2003) instrument for measuring teacher commitment to instructional practices in mathematics that were supportive of reform-oriented approaches. Items were adapted to reflect the underlying principles (e.g., student struggle time on challenging problems is important) and practices (e.g., student thinking and reasoning can be elicited through thoughtful questioning by the teacher) emphasised in BNL. It contained 20 items designed to measure teachers' perspectives about mathematics learning and teaching across seven dimensions. Due to space limitations, data for only two dimensions are reported here. A 3-item measure of student struggle and 4-items measuring the nature of mathematics tasks were obtained using a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). The items for each dimension are presented in Table 1.

Table 1
Items on the struggle and tasks dimensions of the questionnaire

No.	Questionnaire Item	Dimension
1	I start lessons by explaining to students how they should do the task.	Struggle
3	I allow students to struggle before I intervene.	Struggle
15	I don't necessarily answer students' maths questions but rather let them puzzle things out for themselves.	Struggle
4	I like to use maths problems that can be solved in many ways.	Tasks

5	I regularly have my students work through real-life maths problems that are of interest to them.	Tasks
12	When students are working on maths problems, I put more emphasis on getting the correct answer than on the process followed.*	Tasks
14	I often provide the same task for all students and then offer enabling and extending prompts.	Tasks

Note. * Reverse scored item.

As a check for agreement bias, Item 12 was negatively worded and reverse scored (Creswell, 2003). The questionnaire took participants approximately 25 minutes to complete and demonstrated strong reliability with an internal consistency co-efficient of α =.732.

Lesson observations and interviews. Semi-structured interviews were conducted in the final term of the year at participants' schools and lasted approximately 40 minutes. Interviews usually took place soon after a classroom visit to allow for observation of a mathematics lesson taught by the teacher and to elicit conversations about the nature of the lesson and tasks observed. During the interviews, teachers were asked to elaborate upon reasons for selecting particular tasks and instructional practices they employed as well as commenting on how and why any of these aspects had changed as a result of their involvement in BNL. All interviews were audio-recorded and transcribed for analysis. Fieldnotes combined with photographs were taken during lesson observations.

Data analysis. Data from the questionnaire were analysed using SPSS Statistics, Version 25. A combination of correlational analysis and analysis of variance to determine differences between participants' item scores between Time 1 and 2 were employed. Interviews were analysed via a deductive process using the adapted Clark and Peterson (1986) model to guide interpretations of changes at the individual teacher level. Observational data, including data generated from field notes and photographs, were used to provide evidence and elaborations of what teachers described as newly adopted practices.

Results and Discussion

Questionnaire

Table 2 presents the total mean scores of the questionnaire and the mean scores for the Struggle and Tasks subscales for the 239 participants who completed the questionnaire both times and who could be identified by their unique ID code. A repeated measures Analysis of Variance (ANOVA) on continuous variables (total score, subscale and item scores) revealed that total questionnaire scores significantly differed between Time 1 and Time 2, F (1,238 = 323.64), $p < 0.001$, $\eta^2_p = .576$, with Time 2 scores higher than Time 1. Additionally, participants reported higher scores at Time 2 for each of the Struggle (F (1,238) = 247. 55, $p < 0.001$, $\eta^2_p = .510$) and Tasks subscales (F (1, 238) = 163.24, $p < 0.001$, $\eta^2_p = .407$). Higher scores at Time 2 indicate that there was an overall shift in teachers' commitment towards the conceptions of teaching and learning mathematics and the instructional practices emphasised in BNL at the end of 2018 than reported by teachers prior to their involvement in the PL.

Table 2
Means of questionnaire scores across Time 1 and Time 2 for each subscale (n= 239)

Questionnaire Score	Time 1 *Mean* (standard error)	Time 2 *Mean* (standard error)

Total Score	74.34 (.416)	81.75 (.393)
Subscale Scores*		
Struggle	10.03 (.118)	11.94 (.093)
Tasks	15.46 (.116)	17.17 (.101)

Note. Subscale score = the total score on each subscale averaged across participants.

More specifically, the higher mean scores on the Struggle subscale at Time 2 indicate that teachers were more likely to allow their students to independently solve challenging tasks with less intervention or 'telling' from themselves. These responses imply that the teachers' tolerance for student struggle had increased as a result of their participation in BNL. Similarly, higher mean scores on the Tasks subscale show that teachers were now more likely to implement open-ended mathematics tasks that could be differentiated for a range of student capacities and to place greater emphasis on mathematical processes such as reasoning, communication and understanding.

Observations and Interview

Interview and observational data relating to teacher pedagogical knowledge and classroom action components of Clark and Peterson's (1986) model are used to shed light upon how the shifts in teacher questionnaire responses relating to student struggle and the nature of tasks looked like in practice. Data are drawn from just two of the 15 teachers whose lessons were observed and a follow-up interview was conducted. Natalie and Anna, a Year 3/4/5/6 and a kindergarten teacher respectively, were from the same school in South West Sydney.

The opportunity to investigate and explore challenging tasks with little or no teacher 'telling' was an approach that both Anna and Natialie used to launch their respective lessons. Anna launched her lesson on volume and capacity with her Kindergarten students by holding two different containers in the air and asking them to "predict whether one would hold more than the other or whether they would hold the same". Following the sharing of student predictions, Anna provided nearly ten minutes of exploration time for students to test their predictions at water tubs spread around the room. In the follow-up interview, Anna explained that in the lesson she deliberately intended to give students "plenty of time to investigate volume and capacity". She confirmed that the launch phase of the lesson was intentionally planned to motivate students to explore "without being told the answer or how to solve the problem". Anna commented further that her rationale for adopting this approach in all her lessons was to help stimulate student thinking and reasoning because "there was just not a lot of thinking going on before in terms of how to develop their mathematical thinking". She felt that "BNL has focused on students' talking and working mathematically. I purposefully had a lesson focus on working mathematically".

Natalie launched her whole-class lesson on double-digit addition and subtraction with her multi-age class by writing 17 + 15 on the whiteboard and providing students with individual "think time" to consider their own mental strategies. Students were then asked to explain their strategies to "an elbow buddy". During this talk time, Natalie moved around the room and listened to various pairs of students talk about their strategies before carefully selecting individuals to record their strategies on the whiteboard. After each strategy was recorded, whole class discussion ensued about the strategy (see Figure 1). To summarise the strategy discussion, she asked students to think about and respond to two questions: "what's the same about these strategies?" and "what's different about them?". During the follow-up interview, Natalie confirmed "That's something from BNL, definitely. Just getting them to identify what's the same and what's different I think is so important".

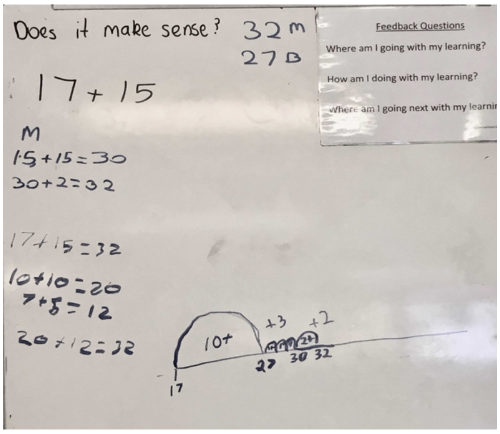

Figure 1. Students' recordings of their mental strategies for solving 17+15 during Natalie's lesson.

Teacher questioning to elicit student thinking was an obvious strategy in both Natalie's and Anna's lessons. However, Natalie felt that "facilitating all that accountable talk, asking thought-provoking questions and open-ended tasks to get children just to really open up and just talk" about their strategies "was not enough". For her, questioning to elicit student reasoning had to be accompanied with "listening or knowing what to listen for" to enable the teacher to appropriately respond to each student's thinking. Natalie expressed her belief that understanding the theory and research underpinning new pedagogies was critical to her being able to enact them in the classroom.

> Anyone can give a child a task, but you need to know the purpose of the task. You need to know what you are looking for in that task. I wouldn't say implementing the task was the challenge. It was the theory of pedagogy underpinning that task that you really need to be aware of and know what it looked like and experiment with how to actually apply it in order to further develop your understanding of what it actually does mean in practice.

At their follow-up interviews Anna and Natalie independently described how the nature of the tasks they used and the pedagogy surrounding the implementation of those tasks had changed to be "more challenging" for students and implemented with time for students to investigate, explore and struggle without telling them what or how to do the mathematics. For Natalie, this change in practice was one suggested to her at a BNL session.

> Previously I would model a strategy or strategies for kids … I'm now consciously aware of why I shouldn't be doing that and giving the children opportunities to explore and conduct those investigations and be able to construct their own learning ...

Anna commented in her interview that the "purposeful crafting of problems and the importance" of allowing students time to struggle on tasks was critical if students' mathematical thinking were to advance.

In summary, notable changes to Natalie and Anna's mathematical-task knowledge and practices as a result of their participation in BNL included:

- Lesson launches with little or no explaining how students should do a task;
- Increased time for students to talk with each other and as a whole class;
- Increased opportunities for students to investigate, explore and struggle on tasks without teacher intervention or 'telling';
- Greater use of teacher questioning to elicit student thinking; and
- More noticing, listening and responding to student strategies by teachers.

Conclusion

The research reported in this paper was part of a large PL initiative designed to enhance teacher knowledge and classroom practices for teaching mathematics. Reported changes to teachers' practices regarding student struggle and the nature of tasks they provided their students as a result of their participation in BNL was the focus. Regarding the research question and changes to teachers' mathematical-task knowledge, data from all collection methods (questionnaire, interview and observation) converged to suggest that teachers' understandings of the benefits of challenging tasks, their awareness of the merits of student struggle and teaching with little or no 'telling' all changed to reflect those needed to develop high levels of reasoning and maintain greater cognitive activation in students as tasks unfold. Furthermore, teachers could not only clearly articulate sound theoretical rationales for why each of these aspects were important, but they were able to make connections between their theoretical knowledge and the practices they enacted to successfully elicit student thinking and enhance their mathematical reasoning. While not all teachers who were observed as part of the larger study were at the same level of readiness to accommodate the necessary perspectives into their practices as Natalie and Anna, it was clear that BNL indeed had a transformative effect on the majority of teachers participating in the PL experience.

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