Mathematical Sequences of Connected, Cumulative and Challenging Tasks in the Early Years

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This symposium reports on a project that focused on *Exploring the Use of Mathematical Sequences of Connected, Cumulative and Challenging Tasks (EMC^3*) with students in the early years (Foundation Level to Year 2). The project was funded by the Australian Research Council, Catholic Education Diocese of Parramatta and Melbourne Archdiocese Catholic Schools (LP180100600). Together with industry partners the EMC^3 project was designed to enhance the cognitive and affective experiences of students when learning mathematics by researching teaching approaches that utilise sequences of cognitively challenging tasks.

Paper 1: *Exploring the Potential of Sequences of Connected, Cumulative and Challenging Tasks in the Early Years* [Peter Sullivan, Melody McCormick]

This paper outlines the rationale for the teaching approach the EMC^3 project aimed at studying an approach to teaching and learning mathematics in the early years (students aged 5–9).

Paper 2: *Differentiating Mathematics Instruction through Sequences of Challenging Tasks in the Early Primary Years* [James Russo, Jane Hubbard]

This paper reports on post-program questionnaire data collected from 100 teachers who express their views about the effectiveness of various instructional approaches to support differentiation in mathematics.

Paper 3: *Changing Teacher Practices: A "Slow Burn" or Rapid with "Big Shifts."* [Sharyn Livy, Janette Bobis, Ellen Corovic, Maggie Feng]

This paper reports on interview data collected from five teacher educators who provided support to the teachers when trialing the EMC^3 resources. The focus of this presentation will be on the notable changes to teacher practices.

Paper 4: *The Nature of Leadership and Other Support that Facilitate Innovation and Improvement in Teacher Practice.* [Ann Downton, Janette Bobis]

The final paper reports on survey data collected from 70 teachers about the forms of support that assisted implementation of project resources—in-class support and facilitation of planning.

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Exploring the Potential of Sequences of Connected, Cumulative and Challenging Tasks in the Early Years

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This paper outlines the rationale for, and some elements of, a particular approach to teaching and learning mathematics in the early years. The researchers worked with two school systems to offer both centrally delivered and school-based teacher professional learning, which included the application of illustrative teaching resources. The project gathered a range of data from teachers and leaders on their dispositions and knowledge, as well as the opportunities and constraints they experienced, and the influence these variables had on planning, teaching and student learning outcomes.

The following outlines the rationale for, and some elements of, an Australian Research Council funded project aiming to study a particular approach to teaching and learning mathematics in the early years (students aged 5–9). This contribution provides background information relevant for the other presentations in the symposium. Fundamental to this approach to teaching was the use of sequences of connected, cumulative, and challenging tasks that focused on mathematical content and proficiencies represented in the *Australian Curriculum: Mathematics* (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2020).

Even though it is common for teachers to develop understanding and foster mathematical fluency associated with particular concepts before problem solving and reasoning, termed teaching *for* problem solving (Schroeder & Lester, 1989), the project explored the potential of the reverse. That is, we considered the impact on student learning and engagement when teachers pose problems that allow for student reasoning to occur first, with the intention of building understanding leading to fluency subsequently; this is termed teaching *through* problem solving (Schroeder & Lester, 1989).

The project task design and pedagogical emphasis were informed by two characteristics articulated by the Organisation for Economic Co-operation and Development (OECD) (2019; 2021). The first, agency, relates to students having the ability and will to make active decisions to positively influence their own and others' learning. This implies that students see themselves as not only capable of thinking for themselves but also having the confidence and aspirations to learn. In order to exercise such agency and realise their potential, learners require time initially to struggle productively (Sinha & Kapur, 2021) with problems or tasks without being told what to do by the teacher/educator or other students. During this uninterrupted time students are able to choose their own strategy and form of representation. This pedagogical focus aligns with the teaching through problem solving approach. In terms of emphasising student agency, we encouraged the project teachers to plan experiences that were productively challenging for students. Sullivan et al. (2020) explained that:

> Challenge comes when students do not know how to solve the task and work on the task prior to teacher instruction. Other characteristics of such tasks are that they: build on what students already know; take time; are engaging for students in that they are interested in, and see value persisting with a task; focus on important aspects of mathematics (hopefully as identified or implied in relevant curriculum documents); are simply posed using a relatable narrative; foster connections within mathematics and across domains …. (pp. 32–33)

The second characteristic, inclusion, involves identifying learning experiences and associated pedagogies that maximise opportunities of all learners. As far as possible, in the

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approach we are exploring, all learners are given opportunities to think for themselves and, especially for students experiencing difficulty, are provided support to access the full curriculum. This is elaborated further in Russo and Hubbard (Paper 2) and includes learning experiences in which the activities and tasks are accessible, while still being productively challenging, and with explicit teacher attention to actions that address the needs of individual learners. There are three aspects of the recommended pedagogies that are intended to foster inclusion. First, teachers are encouraged to choose learning experiences that are not only readily accessible for all students but also have the potential for further exploration. Second, teachers prepare specific enabling prompts for students experiencing difficulty and extending prompts for students who complete the set work quickly (see Sullivan et al., 2006). Third, teachers use a particular lesson structure, as summarised below, consistently to provide students with confidence of the ways the lessons develop.

The specific aims of the project were to:

- explore the potential of sequences of connected, cumulative, and challenging tasks that build a trajectory of consolidated learning of mathematics;
- explore responses from teachers, leaders and students when this approach to teaching mathematics is enacted;
- make recommendations for resource developers, curriculum designers and providers of teacher professional learning.

An Instructional Model for Student-centred Structured Inquiry

The EMC^3 project described this approach to instruction as *Student-centred Structured Inquiry* (the key elements of this are elaborated in Sullivan et al., 2020). The approach is also described as cognitive activation. Caro et al. (2016) analysed results of PISA 2012 involving over 500,000 students and provided compelling evidence of the effectiveness of this perspective. Characteristics of cognitive activation include posing problems that require students to think for an extended time, to choose their own solution procedures, to learn from mistakes, to explain their solution strategies and to solve problems in different ways.

To communicate the various associated teacher actions, the project participants and researchers developed an instructional model with four phases: *Anticipate, Launch, Explore, and Summarise/review*. The language of the instructional model draws heavily on Smith and Stein (2011) who focus on orchestrating classroom discussions, an essential element of creating opportunities for fostering student agency and inclusion. The aim is to make it obvious to students they have a role to play in creating new knowledge.

Anticipate phase. This phase is central to all planning. It includes identifying the intended learning outcomes (what, why and how); developing helpful resources; predicting students' solutions, strategies and possible misconceptions; and considering pre-requisite and new language, as well as other aspects of planning.

Launch phase. This phase addresses language and representation associated with the intended learning experiences. It includes providing opportunities for students to develop fluency in the mathematical processes and procedures relevant to the experiences. It also involves posing tasks without informing students on how to solve the problem, an essential aspect of fostering agency.

Explore phase. In this phase teachers interact with students, encouraging persistence, posing prompts, and identifying interesting and perhaps unanticipated solutions, selecting some for later presentation.

Summarise/review phase. This phase involves the teachers selecting and sequencing student solutions to be shared. Engagement is promoted by supporting students while they present their solutions and encouraging active participation of others. A key element of this phase is the teacher synthesising the essential ideas that represent the learning intentions of the experience.

Importantly, the launch-explore-summarise/review process happens more than once for each learning experience, with the tasks for the subsequent cycles based on Variation Theory (Kullberg et al., 2013). The variations, as represented by this theory, are intended to draw the attention of students to key elements of concepts by varying some aspects while keeping other aspects invariant. In other words, task design involves creating new tasks from existing tasks by keeping some aspects the same but varying other aspects. The variant might be the context, with the concept(s) staying the same. Alternatively, the variant might be the sophistication of the concept (or even the concept itself), with the context staying the same. The explicit intention of the subsequent iterations of the model is to consolidate thinking activated by the initial experience (Dooley, 2012). This consolidation involves repeating the preceding three phases, noting that consolidation can be in a subsequent lesson.

An important feature of the instructional model is that, when consistently applied, it is argued to help students to moderate their anxiety by normalising uncertainty. Buckley and Sullivan (2021) argued that students who are anxious can manage the threat to their learning opportunity by specific behavioural strategies and through familiarity with this lesson structure.

Project Resources

The project team and participating teachers developed coherent and connected sequences, representing the content descriptions and proficiencies of the *Australian Curriculum: Mathematics* (ACARA, 2020). The sequences were intended to make the mathematical ideas central to the learning obvious to the students. Participating teachers were provided with illustrative resources to support the implementation of the pedagogical approach. An example of a low floor/high ceiling task, focusing on making and naming polygons, that is intended to be productively challenging for students aged 6–8 is as follows.

Making polygons out of trapeziums

Using some or all of four trapeziums (all the same), what polygons can you make?
Draw the new polygons on isometric dot paper and name them.
How are your new polygons the same? How are they different?

Students are provided with sets of trapeziums such as those in Pattern Blocks and isometric dot paper. The “floor” is when students make and draw one polygon. The “ceiling” is the possibility of making and drawing multiple different shapes (there are many). An example of an enabling prompt is “what shapes can you make with two trapeziums?” An example of an extending prompt is “draw a triangle made out of three trapeziums without using the materials”. An example of a consolidating task is as follows:

Making polygons out of rhombuses

Using some or all of four rhombuses (all the same), what polygons can you make?
Draw the new polygons on isometric dot paper and name them.
How are your new polygons the same? How are they different?

Even though acknowledging individual students’ thinking as paramount, both the mathematical focus and the pedagogical approach are intentional and go beyond unstructured inquiry or play (Bruner, 1961; Mayer, 2004). At the same time, the approach rejects the notion that the optimal way to teach mathematics is by explicitly telling students what to do, followed by practice. The teacher has an active role, but this happens after students have had the opportunity to engage in the mathematics and the contexts of the tasks. Likewise, students are exposed to illustrative worked examples, some of which can come from the students themselves.

By proposing carefully constructed and effectively trialled sequences supported by related professional learning, teachers can experience not only ways in which learning can be sequenced but also how sequences enhance learning opportunities for students. The goal of offering suggestions for teachers was to free up energy for them to engage with the complexity of converting tasks, lessons and sequences into learning experiences for their students. The aim was to support the development of manageable and sustainable teaching practices. Part of the professional learning for participating teachers was illustration of ways of adapting the contextual stories and including the level of challenge to suit their particular class and student context. Participating teachers took an active role in the adaptation of the tasks, lessons and sequences, not only improving on the initial designs but also gaining insight into the process of sequence creation.

The project partnered with two school systems that invited schools to participate. In each of three years, participating teachers were offered an initial day of professional learning on the goals and resources of the project, were supported in their schools by researchers and system educators and offered further professional learning. Resources were made available in both hard copy and electronically. There were two sets of participants for each partner over the three years (due to COVID challenges). Data were collected from teachers, school-based leaders and system educators through surveys in each year of the project. There were also interviews with teachers and educators, classroom observations, and assessment of student learning. The findings of the project are in the process of publication.

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Differentiating Mathematics Instruction through Sequences of Challenging Tasks in the Early Primary Years

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We report on questionnaire data gathered from teacher participants (n = 100) following their participation in the project, Exploring Mathematical Sequences of Connected, Cumulative and Challenging Tasks. Teachers shared their views about the effectiveness of various instructional approaches to support differentiation in mathematics, including those illuminated through the project, and a description of a lesson involving effective differentiation.

Differentiating instruction in the context of mathematics teaching refers to the suite of strategies that teachers draw on to cater adaptively to the learning needs of heterogeneous groups of students, with the explicit aim of improving mathematical learning outcomes (Russo et al., 2021). Effective differentiation is acknowledged as a particularly demanding aspect of classroom teaching, with Shernoff et al. (2011) finding that "teaching large heterogeneous groups of learners" (p. 65) was the most notable student-related source of job stress for teachers, alongside "managing disruptive behaviour" (p. 64). There is further evidence that identifying and accessing appropriate learning tasks to meet the range of student learning needs is particularly challenging for teachers. For example, Gaitas and Alves Martins (2017) found that primary school teachers view the matching of activities and materials to the diversity of student characteristics, in relation to their academic readiness, interests and learning profiles, as the most difficult aspect of differentiating instruction effectively.

There is also evidence that without opportunities to develop further their pedagogical content knowledge, teachers may struggle to realise the differentiation potential of a given task. Bardy et al. (2021) found that German secondary mathematics teachers tended to be more focused on the surface structure of tasks (such as their layout) and less focused on the deeper design features (such as the adaptive features of the task), compared with mathematics task design experts. The authors concluded by noting that realising the full potential of a task, or sequence of tasks, to effectively support differentiation requires specific expertise and therefore targeted professional learning support for teachers. Despite its relevance to practitioners and implications for equity, the beliefs and practices about how teachers attempt to differentiate instruction by providing rich learning opportunities for all students remains insufficiently researched in the early years of schooling (Bobis et al., 2021).

We are currently involved in a research project, *Exploring Mathematical Sequences of Connected, Cumulative and Challenging Tasks (EMC³)* (Sullivan et al., 2020). A key component of the EMC³ project is a consideration of the extent to which teaching with sequences of challenging mathematical tasks supports differentiation in the mathematics classroom, through both low floor/high ceiling tasks, enabling and extending prompts, and purposeful tasks designed to consolidate learning after productive classroom dialogue about solution strategies. Importantly, given what we know about what teachers find particularly difficult in relation to differentiation (Gaitas & Alves Martins, 2017), participating teachers were provided with illustrative resources to support the implementation of the pedagogical approach, whilst also being encouraged to take an active role in the adaptation of the tasks, lessons and sequences to their particular context. The pedagogical approach presented to teachers in the EMC³ project, including how it supports differentiated instruction, is elaborated on in Sullivan and McCormick (Paper 1, this symposium). The research questions we will briefly explore in this paper include:

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(1) *To what extent do teachers view pedagogies promoted through the EMC^3 project as an effective means of differentiating mathematics instruction relative to other instructional approaches?*

(2) *How do EMC^3 project teachers describe their approach for differentiating mathematics instruction effectively?*

Method

Participants in this study were Foundation to Year 2 (F–2) generalist Australian primary teachers who were involved in the EMC3 professional learning program during 2019 (n = 100). Teachers were introduced to the EMC3 approach during a full day of professional learning with the research team at the start of the school year. They were provided with sequences of challenging tasks and suggestions for their implementation. Support for enactment of the approach was provided to teachers through school visits from members of the project team. Participants also engaged in a second professional learning day in November of 2019. The purpose of day two was to provide teachers with an opportunity to share their post-program learnings and insights with teachers from other schools, as well as to consolidate their understanding around the instructional approach. Teachers were then invited to complete a questionnaire, including questions focussing on their beliefs and approaches for differentiating mathematics instruction. These data form the focus of the current paper.

Results

Perceived Usefulness of Instructional Approaches for Supporting Differentiation

Teachers were asked to indicate the degree to which they considered various approaches useful for differentiating mathematics instruction by responding to the prompt: *The following teaching approaches are useful for catering to students of different performance levels in the mathematics classroom*. For each of the approaches listed, participants recorded their response on a 7-point Likert-type scale, presented with two anchors (1-not at all useful; 7-extremely useful). Mean scores and the percentage of teachers' responses were calculated for each approach. See Bobis et al. (2021) for a more elaborate discussion of this data.

The data from the post-program questionnaire (Table 1) revealed that three teaching approaches were viewed by the majority of teachers as useful for catering to students of different performance levels in the mathematics classroom: problem solving—prompts; problem solving—low floor, high ceiling; and mixed game. These three approaches have important similarities. Most notably, they are the only three approaches of the eight listed that do not involve some form of a priori grouping of students according to perceived mathematical performance, whether such groupings take place within the classroom (grouped game; grouped rotations; grouped online; grouped worksheets) or between classrooms (fluid groupings). It is particularly encouraging that as many as 90% of teachers believed that differentiating problem solving tasks through students accessing enabling and extending prompts was a useful means of catering to different performance levels, with half of the teachers describing this approach as extremely useful. Such tasks formed the core of the learning sequences that teachers accessed as part of EMC^3, and the implication is that this approach was effective at allowing students of all levels to access the tasks. Our second research question focuses on how the teachers described effective differentiation.

Table 1
Usefulness of Approaches for Catering to Students of Different Performance Levels (n = 100)

Instructional Approach	Mean score	positive (5, 6, 7)	extremely useful (7)	not at all useful (1)
Presenting the whole class with the same core problem-solving task, differentiated through students accessing enabling and extending prompts*	6.12	90%	50%	0%
Presenting the whole class with the same core problem-solving task, differentiated through the task having a "low floor, high ceiling"*	5.65	83%	33%	1%
Playing the same mathematical game with the whole class in mixed-performing groups, with the game "naturally" differentiated through students using strategies of choice	5.55	83%	23%	1%
Playing the same mathematical game with the whole class in similar-performing groups, with the game differentiated through groups using resources matched to their performance level	4.36	46%	11%	3%
Between class performance grouping ("fluid groupings"), where similar-performing students are grouped together across classes and undertake activities that match their performance level	3.41	35%	3%	21%
Within class performance grouping, where similar-performing groups rotate through workstations undertaking activities matched to their performance level	3.27	28%	1%	21%
Allowing students to work through on-line activities/Apps at different levels of challenge, depending on their performance level	3.11	27%	4%	21%
Allowing students to work through worksheets at different levels of challenge, depending on their performance level	2.65	24%	4%	44%

*Instructional approach promoted through the EMC3 project

Teacher Descriptions of Effective Differentiation

Participating teachers (*n* = 94) responded to the following open-ended item post-program questionnaire prompt: *Think of a time in which you feel like you effectively catered to students of different performance levels in your mathematics classroom. Describe the lesson in as much detail as possible, including the structure of the lesson, the tasks and activities, your role as a teacher and what your students were doing.* Teacher responses were detailed, varied and extensive. From a mathematical content perspective, 69% of teachers specifically described a number lesson, 14% as a measurement lesson, and 9% as a geometry lesson. Some responses did not provide details for a particular content area but explained strategies for differentiation (9%). The majority of responses referred explicitly to lessons that were part of the EMC^3 project resources. Although all teachers implicitly or explicitly referred to using something that could be construed as an enabling and/or extending prompt to support their effectively differentiated lesson, three other notable themes that supported teachers to effectively differentiate instruction emerged: *the role of the teacher* (64%); *provisions to establish student agency* (53%); and *opportunities for peer learning* (48%).

The role of the teacher. The comments teachers made about their role in differentiated instruction reflect the active nature of teaching when supporting effective differentiation. To ensure learning remained student-centred, teachers described the ongoing adaptations and pedagogical actions deployed both in planning and during lessons to meet student learning needs. Many of these teacher actions to support individual student learning needs paradoxically occurred at a whole class level. For example, teachers described how they made sure the task was set within a familiar context to support all students in comprehending the task and accessing the mathematics more readily. Other adaptations that supported all students included sharing students' work and prompting class discussions. Many teachers acknowledged that the use of open, prompting questions was helpful in initiating mathematically focussed discussions around the task. This included both general questions posed at a whole class level, as well as specific questions to target individual students.

Provisions to establish student agency. Teachers reported the different ways that students were afforded agency in how they approached the task, represented their thinking, and organised their solutions. The use of concrete materials, visual representations and recording templates were frequently mentioned as intentionally provided to support students in making choices as to how they communicated their thinking in meaningful ways. A different perspective on student agency encompassed comments that referred to class norms and consistent expectations that students persist when solving challenging tasks. Student friendly phrases such as "sweaty brain time" indicated a shared expectation that students needed to think for themselves and be willing to work hard to make sense of the mathematics.

Opportunities for peer learning. The data reflected widespread recognition of the role of peer learning when supporting differentiated instruction. Although reference to small groups and paired work featured throughout, orchestrating opportunities for class discussions were the more prevalent examples of peer learning. One frequently mentioned strategy was the use of "spotlights" to present student work for collective discussion during the explore phase of the lesson. Creating opportunities to share student work highlights how teachers draw on specific examples of student thinking to scaffold learning for the rest of the class. Sharing alternative strategies can support other students in considering alternative solutions, maintaining motivation, and/or consolidating learning.

Summary

Teachers viewed the pedagogical approaches emphasised through the EMC^3 project resources, particularly tasks differentiated through enabling and extending prompts, as more effective for differentiating instruction than other approaches. Moreover, teachers viewed effective differentiation in mathematics as being supported by several factors including: providing students with enabling and extending prompts; the teacher being in an active role during the lesson, facilitating adaptations to meet learning needs; providing opportunities for students to exercise agency; and adopting structures to support peer learning.

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Changing Teacher Practices: A "Slow Burn" or Rapid with "Big Shifts"

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This paper focuses on the time teachers take to adapt to a student-centred inquiry approach to teaching mathematics, the nature of those changes and the reasons for variations in both these aspects among teachers within and across schools. Five numeracy experts, who worked with 200 Foundation to Year 2 teachers to facilitate the implementation of the approach, were individually interviewed at the end of the year to obtain their perspectives on teachers' adaptation. Thematic analysis of the data revealed two overarching themes—context and teacher agency. The findings reinforce recommendations that professional learning providers acknowledge and take account of individual teacher learning trajectories to maximise potential change in practices.

Most experts in the field of teacher professional learning consider achieving significant change to teachers' practices to be a difficult and slow process (e.g., Guskey, 2003). However, there are examples constantly emerging of teachers who have made profound changes to their beliefs and practices in relatively short periods of time (e.g., Bobis et al., 2016). Those studying the reasons for the differential impact of professional learning interventions on teachers have taken different perspectives. For instance, Huberman (1993) and Brunetti and Marston (2018) identified numerous phases or career stages that teachers characteristically experience as part of their professional development journeys. Huberman also developed several models representing the potential reasons for variations in teacher developmental trajectories. Similarly, Gregoire (2003) proposed a model of teacher conceptual change accounting for affective and cognitive teacher characteristics that could potentially determine variations in teacher readiness to change their beliefs and practices. Together, these studies reveal commonalities of teacher learning and suggest potential reasons for variations in the time individual teachers take and the degree to which change occurs. In particular, the findings highlight the importance of context (physical and social environment) and teacher agency (their sense of empowerment and willingness to act) to help facilitate change. Brunetti and Marston (2018) explain that the influence of context on teacher development needs to be studied in terms of both *space* (e.g., school resources and leadership) and *time* (e.g., teacher prior learning). Importantly, a connection between context and teacher agency exists. In exploring this connection, Beauchamp and Thomas (2009) suggested that a strong sense of teacher agency has the power to "transform the context" (p. 183). This means that even in the face of contextual constraints, teachers with a strong sense of agency can still experience rapid and big shifts in their approaches to teaching.

The focus of this paper is on the time teachers take to adapt to a student-centred inquiry approach to teaching mathematics, the nature of those changes and the reasons for variations in both these aspects across schools and among teachers within schools. An understanding of such development is important to school and system leaders, and designers of professional learning (PL) to ensure they appropriately respond to the professional needs of teachers.

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Background to the Study and Setting

This study was conducted as part of a large, funded research project, *Exploring Mathematical Sequences of Connected, Cumulative and Challenging Tasks (EMC³).* This project involved working with approximately 200 Foundation to Year 2 (F-2) teachers from 19 different schools across two Australian states of New South Wales and Victoria each year for three years in a PL intervention. Following PL days conducted at the start of each school year, teachers implemented multiple sequences of challenging tasks utilising a student-centred inquiry approach that is described in detail by Sullivan et al. (2020) and outlined in Sullivan and McCormick (Paper 1) as part of this symposium. To support implementation of the approach, one school system participating in the project, engaged five system-level numeracy content-specific experts referred to as Teaching Educators (TEs), to assist individual schools and teachers. The nature of their support is detailed in Downton et al. (Paper 4) as part of this symposium, but in brief, TEs assisted individuals and teams of teachers to plan and teach the sequences. They also regularly observed lessons and facilitated post-lesson debriefing sessions where teacher practices and student responses were unpacked. TEs are highly experienced primary teachers and leaders with a mathematical subject and pedagogic expertise beyond the norm of primary classroom teachers. TEs received additional PL from the research team and remained involved in the project implementation for at least three years. Every year of the project implementation, each TE was allocated between two and four school teams of F-2 teachers (approx. 3-16 teachers per school depending on the school size) to assist in their implementation of the sequences and the associated EMC³ teaching approach.

The research questions were: (1) What were the most notable changes to teacher practices resulting from their involvement in the project? (2) Why did teachers vary in the degree of change and the time it took to adapt to a student-centred inquiry approach?

Method

Participants and Data Collection Process

Participants in this study were five TEs. Working closely with teams of teachers to plan and implement the project in classrooms, they were ideally placed to comment on teachers' adaptation to the new practices inherent in the approach. At the end of the first year of the project's implementation, each TE was individually interviewed for approximately one hour to gain their perspectives on the project's strengths and shortcomings. One aspect of this semi-structured interview focused on changes to teacher practices that the TEs perceived. For example, TEs were asked to comment on practices teachers used to launch challenging tasks, to elicit student thinking and conduct class discussions as they supported student learning. They were also asked to: (a) describe how these practices had changed over the time of the project's implementation; and (b) provide their perspective on the reasons for variations in teacher adaption to the approach. All interviews were audio recorded and transcribed for later analysis.

Data Analysis

Interview data were analysed thematically using an adaptation of Braun and Clarke's (2006) approach. A process of reading for familiarity, followed by coding using both deductive and inductive means before identifying themes that helped capture the notable features of the data that were considered most relevant to addressing the research questions. For instance, we approached coding the interviews knowing that we were interested in the reasons for variations in time and intensity of teacher adaption to the approach advocated during the PL component of the project. However, we did not know which practices or aspects of the approach teachers would find more challenging to adapt to and why.

Results

In this section, we briefly identify the most notable changes to teacher practices that TEs perceived took place during the project. We then identify the themes and sub-themes that emerged from the analysis of interview data that helped to explain the variations in the degree of change and in the amount of time individual teachers or teams of teachers took to adapt to the EMC^3 approach. Pseudonyms are used when reporting TEs responses.

All five of the TEs identified "the biggest shift … has been the pedagogy of launch, explore, summarise and holding back from telling" [Athena]. Elise estimated that "80 per cent of the teachers I am working with are launching without telling or at least trying" and Athena thought that "75% of them are on board and doing a great job with the launch … holding back from telling." Although the biggest shift in practice had been teaching "without telling," Diane felt that it was "different for all the teachers" and that "the launch phase" without telling "was still a challenge for some." Nancy considered that even though the teachers at one of her schools were already familiar with the lesson structure, the "not telling" was new.

> They've changed their practice in terms of less teacher talk … and not doing too much telling. [Nancy]

Thematic analysis of the data revealed two overarching themes in the TEs' explanations for the variation in time teachers took to adapt to the EMC^3 approach—context and teacher agency. Context in space and in time emerged as important reasons why the process of adaptation was "a slow burn" [Athena] or rapid with "big shifts" [Elise] in teacher practices.

Context in space. Variation in the availability of support from their numeracy leadership team members was regularly highlighted as a reason why some teachers found it easier to adapt in their school spaces than others.

> They plan their program together; so, there's three teachers in each space. They've got two class teachers and one diversity support teacher, plus the numeracy leader plus the instructional leader; so, it's many heads, they are very focused. But at School R, which just has the instructional leader, there was several staff who didn't have much buy-in. there's been a bit of a staff turnover…Their numeracy leader only has one day [a week], so she's trying really hard to catch them up to speed. [Athena]

In terms of physical resources, Megan considered that "it's been really helpful to have the tasks there so they can focus" on the pedagogical approach. However, she realised that sometimes the classroom space itself acted as a constraint for teachers to adapt to new practices when "the room can be noisy, … it's a shared space."

Context in time. Regardless of the rate and extent to which schools and teachers adapted to the approach, the five TEs agreed that individual teachers commenced the project at "different starting points" [Nancy] in terms of their knowledge and practices. Prior PL associated with challenging tasks meant that some teachers could "go deeper with the maths" [Megan] from the start. The variation in teacher readiness to adapt to certain aspects of the teaching approach meant that TEs had to be flexible in how they worked with individuals and groups of teachers.

> At School M they were already on this trajectory of deepening teachers' understanding about math tasks. They had done a lot of professional learning around mathematics already … At my other school, staff who didn't have much buy-in had missed out on the professional learning. [Athena]

> At my first school … the kids are used to talking about the maths and used to explaining their thinking and turning and talking to their learning partner. My other school, we're not at that point yet. We tend to give them some little props sentence starters to get the kids talking … but they've gotten better. [Nancy]

Teacher agency. Teacher agency was characterised by examples of teacher resilience to work (or not work) hard in the face of challenge. Elise remarked that at one of her "slow burn" schools, the teachers showed little agency at the beginning as they "thought all of the tasks … were too challenging" and "there was no encouragement to try" for many months. Most teachers, however, were described by TEs as “really working hard” [Megan, Athena and Elise] despite the challenges of adapting to a new teaching approach.

Agency was also exemplified by increases in teacher efficacy. Teachers perceived to be slower in adapting to the approach were described by TEs as initially “hesitant” or “afraid … of the challenge.” However, “in the doing there has become believing” and growth in the belief that they “could make the approach work.” [Athena]

> … it’s been a bit of a slow burn for them. But they are on board; they are positive, and they are thinking that they’re doing a good job. [Elise]

Discussion and Conclusion

In accordance with prior research (e.g., Brunetti & Marston, 2018; Beauchamp & Thomas, 2009), our findings show that context (in space and in time) and teacher agency were central to explaining variations in the time teachers take to adapt to change. Teachers with a strong sense of agency were perceived by TEs to be more willing to work hard and try new practices despite contextual constraints. As the results of this study show, the important point is that teachers must be active in the process of professional learning for any form of change to occur. The findings reinforce recommendations initially expressed by Huberman (1993) and reinforced by Brunetti and Marston that providers of PL need to acknowledge and take account of individual teacher trajectories of learning (context in time) to maximise the potential of teachers adapting to new approaches. In the current study, TEs could adapt to the nature and extent of support individual teachers required. An understanding of school contexts and a sense of individual teacher agency are important to school and system leaders, and to designers of PL to ensure they appropriately respond to the professional needs of teachers.

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The Nature of Leadership and Other Support that Facilitate Innovation and Improvement in Teacher Practice

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In the context of a professional learning research project we investigated the nature of support offered to classroom teachers and school mathematics leaders to facilitate teachers' implementation of sequences of challenging tasks. End of year questionnaire data were collected from 70 Foundation to Year 2 teachers and ten numeracy leaders who participated in the project. Thematic analysis was used to analyse the open response questionnaire items. Findings reveal that two forms of support were helpful: in-class support, such as co-teaching, observation, followed by co-debriefing; and facilitated planning prior to instruction.

It is widely acknowledged that professional learning assists teachers to implement innovative pedagogical practices to enhance the teaching and learning of mathematics and ultimately improve students' learning outcomes (Akiba & Liang, 2016; Bobis et al., 2005). For professional learning to be effective there needs to be a bridge between research and classroom practice (Kretlow et al., 2012). Such a bridge is provided by external coaches or experts associated with an education system, who are educators with specialist expertise. These external experts are considered critical to the effective implementation of the new learning in schools (e.g., Cobb et al., 2018; Timperley et. al., 2007). They work in partnership with school leadership teams and their role includes collaborative professional support, mentoring school-based mathematics leaders, in-classroom instructional support, and leading professional learning within schools (e.g., Cobb et al., 2018). Critical to their work is the engagement of teachers in dialogue about the mathematical content, pedagogical practices and student learning (Campbell & Griffin, 2017). In this paper, these specialised coaches are referred to as Teaching Educators (TEs). These educators possess content-specific expertise and are employed by a school system to support school-based leaders and teachers to improve the quality of teaching and learning of mathematics.

Studies have highlighted the important role school-based mathematics leaders play in supporting teachers to implement new practices as part of a professional learning project (e.g., Sexton & Downton, 2014). Unlike the external coaches, these school-based leaders often have classroom responsibilities as well as their leadership responsibilities outside the classroom (Wenner & Campbell, 2017). Support by both the coaches and school-based numeracy leaders is provided alongside the daily work of teachers in the classroom, and is characterised by a cycle of planning, practice and reflection (Bruce et al., 2010). These studies highlight the importance of having both external and school-based support for teachers as they implement new learning.

The study reported in this symposium paper is part of the *Exploring Mathematical Sequences of Connected, Cumulative and Challenging Tasks* (EMC^3) funded research project (Sullivan et al., 2020). Details of the project are provided in Sullivan and McCormick as part of this symposium (Paper 1). The focus of this study was the nature of leadership support provided by TEs and school-based leaders to classroom teachers to facilitate the implementation of innovative practices. The research question was:

What leadership supports are provided for classroom teachers during the implementation of innovative pedagogical practices involving challenging mathematics tasks?

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Method

Participants in the study were Foundation to Year 2 (F–2) teachers involved in the EMC[3] professional learning (PL) program during 2019 (n = 70); five Lead Numeracy teachers (LNT); and five TEs employed by the school system who worked in project schools to support the LNT and teachers implement the new learning in the classroom. Some schools had an Instructional Leader (IL) who supported the LNT and classroom teachers. TEs followed up the main PL delivered by the researchers at the start of the year by facilitating PL in project schools at a point of need; implementing the co-teaching cycle (co-planning, co-teaching and co-debriefing) with LNT and classroom teachers, and observing and acting as a “guide on the side” (Morrison, 2014) for both LNT and teachers. At the second PL day in November participants completed a questionnaire that included open response questions focused on how they were supported in the classroom and in planning. We adapted Braun and Clarke’s (2006) thematic approach to analyse the open response items. Responses were collated, then categorised according to themes that emerged from the data. Where participants had written multiple ideas in one response, each was categorised and coded.

Results

Seven main themes emerged from the analysis of the two open response items—one relating to how teachers were supported in the classroom and the other to how they were supported in planning. The results are presented in Tables 1 and 2 respectively.

Table 1
Themes Relating to Classroom Support Frequency of Responses and Illustrative Quotes

Theme	Illustrative quotes
1. Team teaching or co-teaching (n = 38)	TE taught in-situ with us and gave us an opportunity to reflect on our teaching and work with us to know where to take the students with their learning TE visited the classroom and co-taught with me so I could learn some new and different questioning techniques and enabling & extending prompts.
2. Providing feedback (n = 22)	[TE] feedback/feed forward time afterwards allowed me to get a better picture of the students' success and where to next.
3. Pre and post lesson discussions (n = 20)	Meeting with both [TE and LNT] to talk out the lessons, and time to prepare lessons was always helpful. We were given time to plan with our TE and lead numeracy teacher.
4. Modelling lessons (including reflections) (n = 19)	TEs modelled how the lesson structure should be like in the classroom. [TE] was also happy to run some parts of lessons (especially the reflections), which enhanced my learning and student learning.
5. Leaders helped them feel comfortable and supported (n = 8)	TE gave me confidence to not explicitly teacher rather let students explore. Both the TE and LNT were AMAZING support during the sequences TE supported me so much as a new LNT - I couldn’t have done it without her!
6. Assisted with the reflection stage of the lesson (n = 8)	Our TE demonstrating reflection time throughout the lesson to see how probing questions facilitate the learning of the students. Suggestions given by [the TE] about students thinking to capture and share with the class as well as ways to reflect at the end of the session.
7. Observations by leaders (n = 4)	TE - visited weekly to observe a sequence in action. LNT and TE would come into the room and observe.

Note: TE (Teaching Educator), LNT (Lead Numeracy Teacher).

Table 2

Themes Relating to Planning Support, Frequency of Responses and Illustrative Quotations

Theme	Illustrative quotes
1 Planning (*n* = 58)	The most effective support from [TE] was when we were able to plan together prior to the lesson and anticipate the possible problems or modifications TE also helped with planning of where the students were at and where to begin our sequences as we didn't want to begin where kinder would start etc.
2. Professional learning (*n* = 10)	As someone who hadn't completed the beginning sequences courses it was really great having a release day to sit with the TE and IL [Instructional Leader] to go through tasks. Our TE was also there for our PL and assisted us to notice the maths content of tasks. We went through the tasks with [TE] and tried them out for ourselves. This helped us anticipate possible answer we would of received from the students.
3. In-class support (*n* = 10)	TE would often come into the classroom and work closely with me as a teacher to help see what students' needs were and how best to support them. TE was able to model what this looked like and how to use Talk Moves for more student talk rather than teacher talk.
4. Time (*n* = 16)	Leadership provided us time to plan together as a Stage and with our TE who guided us. Sequence planning time with TE and LNT allowed us to plan for the week.
5. Resources (*n* = 4)	The school were fantastic at giving us …. resources to use during the sequences. Resources were sourced, organised in preparation to teach the sequence by the IL.
6. Data analysis (*n* = 4)	TE and LNT answered all of my questions, in particular to tracking student's development in number through a variety of tasks. Met with the IL and TE to …plan the next steps using evidence of data collected.
7. Feel supported (*n* = 2)	[The TE] was advocating for me as a part-time teacher. We all felt very supported and comfortable to ask our TE questions. It was incredible to have [TE] with us as well. She assisted us to drive the learning.

While some overlap was evident in the data across the two tables, the themes that emerged from the analysis revealed the specific nature of the support provided by TEs in the classroom and in planning. Within the classroom, co-teaching, modelling of the lesson structure, and how to orchestrate the reflection part of a lesson featured prominently in the teachers' responses. The value teachers placed on the feedback they received and suggestions TEs had to progress students' learning, indicate that these teachers respected their advice and were committed to embracing this new pedagogical approach.

TE support with the planning prior to the enactment in the classroom was also recognised as being an important factor in the implementation. The teachers realised the benefit of engaging with the task before instruction, anticipating how the students might respond and the types of prompts that they could employ during the lesson. Some teachers also recognised the planning support as a form of ongoing professional learning for them. Time was a consideration in planning, post-lesson reflection and analysis of the data. Some teachers commented that leadership recognised the need to maximise the learning opportunities when the TEs were in the school and provided additional release time.

Theme 5 (Table 1) and theme 7 (Table 2) highlight the affective aspect of the support the teachers received. Teachers' felt comfortable with the TEs and were very supported when exploring this new learning. Comments related to these and other themes suggest the rapport the TEs had developed with the teachers was critical to the effectiveness of the implementation. Acknowledgment must be given to the support offered by the school-based leaders—LNT and IL who provided ongoing support on a daily basis.

Conclusion

These results highlight the nature of the leadership support that the teachers found beneficial when implementing this innovative pedagogical approach, in particular the support offered by the TEs. Three findings are evident from these results. First, that the support of an external knowledgeable other (TEs), who has an understanding of the philosophy underpinning the project and of the pedagogical approach was essential when expecting teachers to embrace new learning. Second, schools needed to factor in additional time for collaborative planning, debriefing and reflecting on the new learning with TEs and school-based leaders (LNTs). Third, teachers valued and respected the expertise of the TEs and developed a rapport and positive working relationship with them. Building mutual respect and trust was a contributing factor to teachers' willingness to embrace the new learning.

These findings resonate with earlier research related to the importance of an external expert with specialised expertise who works in unison with school leadership teams to support the implementation of new learning (e.g., Cobb et al., 2018; Kretlow et al., 2012; Timperley et. al., 2007). A key difference is that the TEs have a long-standing relationship with the school leadership team, LNTs and ILs had an understanding of school contexts, so they are considered a "guide on the side" (Morrison, 2014) to teachers and a critical friend or mentor to school-based leaders, rather than an expert who provides additional support from time to time. We acknowledge the following limitations of the study. First, the results reflect a small sample, which is not generalisable to the whole population. Second, these results present the responses of teachers only. Future papers will report the TEs perspective.

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