Scandinavian Journal of Educational Research

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/csje20

Supporting In-service Teachers' Collective Learning of Ambitious Teaching Practices Through Teacher Time Outs

Kjersti Wæge & Janne Fauskanger

To cite this article: Kjersti Wæge & Janne Fauskanger (2022): Supporting In-service Teachers' Collective Learning of Ambitious Teaching Practices Through Teacher Time Outs, Scandinavian Journal of Educational Research, DOI: 10.1080/00313831.2022.2042730

To link to this article: https://doi.org/10.1080/00313831.2022.2042730

Published online: 25 Feb 2022.

SCANDINAVIAN JOURNAL OF EDUCATIONAL RESEARCH
https://doi.org/10.1080/00313831.2022.2042730

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Supporting In-service Teachers' Collective Learning of Ambitious Teaching Practices Through Teacher Time Outs

Kjersti Wæge [a] and Janne Fauskanger [a,b]

[a]Norwegian Centre for Mathematics Education, Norwegian University of Science and Technology, Trondheim, Norway; [b]Faculty of Arts and Education, Department of Education and Sports Science, University of Stavanger, Stavanger, Norway

ABSTRACT

The article focuses on Teacher Time Outs (TTOs) in rehearsals and co-enactments as part of a practice-based approach to professional development, aiming to support teachers' learning of ambitious mathematics teaching. Ambitious teaching requires teachers to be responsive to students' ideas in-the-moment of instruction. This is complex and places enormous demands on the teacher. We examine how TTOs support teachers' learning of ambitious teaching and their development of pedagogical judgment. The findings reveal that the TTOs provided opportunities for teachers' collective learning of key practices of ambitious teaching, and that the TTOs supported the teachers' collective pedagogical reasoning and decision-making in-the-moment of teaching and with connecting pedagogical reasoning to pedagogical actions and responsibilities.

ARTICLE HISTORY
Received 8 April 2021
Accepted 10 January 2022

KEYWORDS
Professional development; mathematics teaching; teacher time out; rehearsals; co-enactments; ambitious teaching

Introduction

Ambitious teaching is a complex endeavour that places enormous demands on the teacher. An ambitious teacher elicits and is responsive to students' thinking, orients students to each other's ideas, and uses student responses to guide the class towards deeper understanding of key mathematical ideas (e.g., Lampert et al., 2013). This requires continual learning about the subject matter, and about how to facilitate student understanding and how to promote engagement and make learning meaningful for particular students in particular contexts (Kazemi et al., 2018). As ambitious teaching is grounded in students' emergent ideas, it is crucial for teachers to learn to enact teaching practices that are thoughtfully responsive to students' in-the-moment thinking (Richards & Robertson, 2015).

In their review of research on what is known about teachers' mathematical knowledge for teaching and how this knowledge might be supported through professional development (PD), Hoover et al. (2016) argue that mathematical and pedagogical perspectives should be coordinated in PD to provide teachers with opportunities to learn in and from practice. However, few existing PD designs are structured to support teachers to engage deeply with the complexity of in-the-moment decision-making (Kennedy, 2016). In this article, we explore how a professional learning routine, called Teacher Time Out (TTO), supports teachers' learning of an ambitious mathematics instruction that is thoughtfully responsive to students' in-the-moment thinking. TTOs allow teachers to think out

CONTACT Kjersti Wæge kjersti.wage@ntnu.no

loud together in the moment during real-time instruction and discuss how the teacher might choose to respond to student contributions and determine where to steer the instruction (Gibbons et al., 2017).

Being responsive to students' emergent ideas is one of the most challenging parts of ambitious teaching (Richards & Robertson, 2015) and teachers need to practise with colleagues to learn this. Kavanagh et al. (2020) argue that it is important to design approximations of practice to support teachers' learning of adaptive instruction. Moreover, Charalambous and Delaney (2020) argue that we need research that explores the role of approximations of practice in PD, such as replays, rehearsals and co-enactments. In this article, we focus on two kinds of approximations, *rehearsals* and *co-enactments*, and we examine how TTOs in these approximations support teachers to learn ambitious teaching and develop *pedagogical judgment*. We address the following research questions: (a) What are the patterns of use of TTOs within rehearsals and co-enactments? and (b) In what ways do TTOs in rehearsals and co-enactments provide complementary opportunities for teachers to collectively learn the practices of ambitious mathematics teaching and develop pedagogical judgment?

Our work provides insight into how teachers work collectively to explore the complex demands of in-the-moment instructional decisions in ambitious teaching. We aim to answer the research questions by studying videos of rehearsals and co-enactments. The study is part of the larger *Mastering Ambitious Mathematics teaching* (MAM) project, aiming at supporting teachers' learning of ambitious mathematics teaching. A unique feature of MAM is that it allows teachers the opportunity to immediately try out new ideas with students.

Research on TTOs in Rehearsals and Co-enactments

Studies have investigated how teacher educators work with novice teachers in rehearsals and what novice teachers have opportunities to learn (Kazemi et al., 2016; Lampert et al., 2013; Shaughnessy et al., 2019). The findings are that rehearsals provide opportunities for novice teachers to engage in the interactive work of teaching and in learning key ambitious practices and adaptive teaching while developing knowledge, skills and identities. Ghousseini (2021) has shown how rehearsals afford novice teachers the opportunity to engage in work that enlist mathematical knowledge for teaching, where they have the opportunity to reorganise their mathematical knowledge for teaching and learn when it is most applicable.

There are also some studies on rehearsals in the context of PD. Kavanagh et al. (2020) investigated how rehearsals (their content, tasks, instructional routines and facilitation moves) supported teachers in being responsive to students' ideas. They found that by constraining what teachers could approximate, for example by reducing teachers' choices of task selection, they could better support teachers' learning of adaptive instruction. Munson et al. (2021) showed how rehearsal debriefs might function as a bridge between rehearsals and the complexity of teaching in the classroom. Previous studies within MAM investigated how TTOs in rehearsals supported teachers' learning of ambitious mathematics teaching (Valenta & Wæge, 2017; Wæge & Fauskanger, 2021). Wæge and Fauskanger (2021) found that TTOs enabled learning situations for teachers to collectively learn key practices of ambitious teaching and how to use them adaptively. The findings show that rehearsals were a setting within which the teachers developed, negotiated and shared their understanding of ambitious teaching, enabling them to work simultaneously on multiple practices in relation to each other.

There are few studies on TTOs in co-enactments in PD. Most of the existing research has examined how teachers, teacher educators and school leaders can learn key aspects of ambitious teaching together through "Math Labs" as part of school-wide PD (e.g., Gibbons et al., 2017; Kazemi et al., 2016, 2018). In Math Labs, the participants co-plan and co-enact lessons together. The findings from a study conducted by Gibbons et al. (2017) show that TTOs in co-enactments afforded opportunities for the participants to make changes as the lesson unfolded and to shift the focus of interactions from one of evaluation "to one of collective consideration and opportunistic experimentation in the midst of teaching mathematics" (p. 29). Previous studies within MAM

have examined how TTOs in co-enactments, embedded within learning cycles, support teachers' collective learning of ambitious mathematics teaching (Fauskanger, 2019).

Although the body of research on rehearsals and co-enactments in the context of PD is growing, we still know little about how TTOs in these two different approximations of practice, as part of a learning cycle, work together to provide teachers with opportunities to learn. The aim of this study is to shed light on this.

Theoretical Framework

We take a situative view on teacher learning, aiming to understand learning as it emerges through participation in activity. We draw on Lave's (1991) description of learning, thinking and knowing as "relations among people engaged in activity in, with, and arising from the socially and culturally structured world" (p. 67). From this perspective, teacher learning means developing the ability to engage in particular communities of practice and developing identities. Moreover, we consider teacher learning as non-linear and teacher professional growth as an inevitable and continuing process of learning (Clarke & Hollingsworth, 2002).

Horn (2020) argues that a well-honed pedagogical judgment is crucial to the teachers' practising successful responsive mathematics teaching that is thoughtfully responsive to students' in-the-moment thinking. She claims that pedagogical judgment has three components: pedagogical action, pedagogical reasoning and pedagogical responsibility. Pedagogical action refers to the intentional and unintentional choices teachers make in their role as a teacher. Pedagogical reasoning refers to the interpretations and rationales the teachers provide for these actions: the same action may have different reasons, for example, a teacher may encourage students to collaborate because it is emphasised in the curriculum, because he believes that student collaboration is important for students' learning and understanding or his action may be rooted in both reasons. Pedagogical responsibility is about teachers' sense of their institutional, ethical, legal and moral obligations. According to Horn (2020), PD designs should support the teachers' development of pedagogical judgment and build explicit connections across pedagogical action, pedagogical reasoning and pedagogical responsibility. MAM is designed to help elicit and engage teachers' pedagogical judgment. The learning cycle allows teachers to share their decision-making and reason about their teaching.

Principles and Practices of Ambitious Teaching

The MAM design is informed by a set of principles about ambitious teaching: designing instruction for students to have equitable access to learning; positioning students as sense-makers; engaging deeply with students' thinking; and seeing teaching as both intellectual work and a craft. Moreover, teachers must know their students, and be responsive to them in culturally appropriate ways (Ghousseini et al., 2015; Kazemi, 2017). We organised the PD around the development of a set of teaching practices that are identifiable components of instruction that teachers enact to support learning and consist of "strategies, routines, and moves that can be unpacked and learned by teachers" (Grossman et al., 2018, p. 4). The practices we addressed in MAM include launching problems, using mathematical representations, aiming towards a mathematical goal, facilitating student talk and eliciting and responding to students' mathematical ideas (Lampert et al., 2013). Teachers must work on multiple practices in relation to each other, and according to Chapman (2016) and Charalambous and Delaney (2020), we need to better understand how PD engage teachers in all interconnected aspects of ambitious teaching. The current study aims to explore this matter.

Participants

Thirty teachers from ten public elementary schools in an urban municipality in Norway participated in the MAM project. All elementary schools were invited to send an application for

participation in the project. Ten schools applied, and all were approved. The principals at each of the schools selected three teachers (teaching all subjects) who wanted to learn ambitious teaching and whom they thought could subsequently serve as mentors so the ambitious teaching practice could be expanded to the whole school. The teachers were divided into four teaching groups. When designing the study, we considered that two groups constituted an appropriate size for this study. One group chose not to participate in the research study. We picked two of the remaining three groups at random, thus our study consists of 14 teachers from elementary schools (years 1–7). The teachers had varying experience as mathematics teachers: Five had 1–5 years of experience, three had 6–10 years of experience and six had more than 10 years of experience. Prior to the course, none of the teachers had extensive experience of ambitious teaching.

Setting

MAM consisted of 12 sessions, taking place at one of the participating schools, over a period of two years. The work in nine of the sessions was organised around learning cycles with six phases (see Figure 1). In these sessions, the teachers were divided into four groups of seven to eight participants guided by a teacher educator: (1) *Preparation*. Before the session, the teachers read an article on various themes and watched a video recording of a particular instructional activity. (2) *Collective analysis*. The teachers, guided by a teacher educator, analysed the article and principles and practices central to the instructional activity. (3) *Co-planning*. Groups of teachers and teacher educators co-planned to teach the instructional activity using ambitious practices and principles. (4) *Rehearsal*. One or two of the teachers were teaching the instructional activity while colleagues played the part of students. All participants could pause instruction by initiating a TTO, during which they were discussing how the teacher might choose to respond to student contributions and determine where to steer the instruction (Gibbons et al., 2017). When appropriate, the teacher resumed the enactment of the activity. Each rehearsal was allocated 30 min but was often shorter. (5) *Classroom*

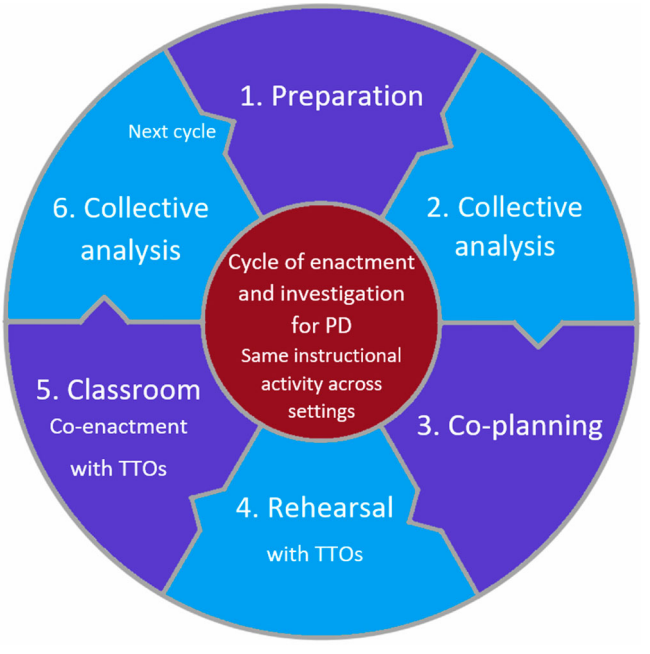

Figure 1. Cycle of enactment and investigation for PD (Wæge & Fauskanger, 2021).

co-enactment. Following the rehearsal, the same teacher(s) enacted the instructional activity with a group of students (aged 11–12). All the participants were responsible for the co-enactment, and as in rehearsals, the participants could initiate TTOs. Each co-enactment was allocated 20–50 min, and the group of teachers met the same group of students each time. (6) *Collective analysis*. In this debrief, each group analysed the enactment and reflected on what they learned by focusing on how the principles and practices played out with students and considering implication for teaching. After this, the whole group met for a collective analysis and reflection on the co-enactments, and preparation for the next cycle.

The focus of our study is on TTOs in rehearsals and co-enactments. We point out that the learning situations enabled by TTOs in these two settings are shaped by the conversations in the other phases of the cycle.

Data Collection and Analysis

We draw on a subset of our data from MAM. Nine rehearsals and nine co-enactments from each of the two teaching groups were analysed, giving a total of 18 video-recorded rehearsals and co-enactments. This article builds on our prior analysis of rehearsals (Wæge & Fauskanger, 2021) to explore the relation between TTOs in rehearsals and co-enactments. We identified a TTO as the point in time when enactment was explicitly paused "so that the teachers and teacher educators could ask questions, think out loud together and consider their instructional decisions before continuing with the instruction" (Wæge & Fauskanger, 2021, p. 8). We used *Sportscode* video-analysis software that allowed detailed coding of the TTOs both within and across video-recorded rehearsals and co-enactments. We created timelines for each rehearsal and co-enactment to capture the TTOs and to code what the participants worked on within each TTO. Coding the video directly allowed for an examination of both verbal and visual cues, such as written representations on the board, gesturing and movements. By analysing TTOs we could explore the teachers' collective engagement and reflections in-the-moment of teaching.

Our prior analysis of rehearsals resulted in eleven codes: launching problems, using mathematical representations, aiming towards a mathematical goal, using talk moves, eliciting and responding to students' mathematical ideas, mathematics, student error and student thinking, organising the board, students writing solutions on the board and anticipating (for descriptions of the codes, see Wæge & Fauskanger, 2021). Building on that, we started the analysis of the co-enactments by coding for these eleven a priori codes. They represent codes that were exemplified in co-enactments in a previous study of the MAM project (Fauskanger, 2019). One additional code emerged from the data identifying an additional aspect that was worked on in the TTOs in co-enactments: "steering instruction". This code concerned deciding where to go next, for example: "Have you thought about a group that you think can start?" In many of the TTOs we used multiple codes to identify the aspects of the practice that were being worked on. Finally, we analysed the TTOs in the rehearsals and co-enactments in relation to each other to identify segments that were connected.

Both authors coded each TTO independently. Disagreements in coding were resolved through review of the TTOs and discussions. We arranged data segments according to common codes and reviewed the entire dataset qualitatively. We constructed tables that helped us to look for common features across the TTOs and to compare TTOs in rehearsals and co-enactments, and throughout the process we wrote analytical memos and reviews concerning connections in the data (Corbin & Strauss, 2008). In the analysis, we explored how the TTOs supported teachers to learn practices and principles of ambitious teaching and connect pedagogical action to pedagogical reasoning and responsibility (Horn, 2020). We selected representative examples from the data, which could be presented without long elaborations on the preceding and succeeding contexts, to present our findings.

Findings

Patterns of TTO Use within Rehearsals and Co-enactments

Here we describe the structure of the analysed rehearsals and co-enactments (Table 1). The rehearsals lasted on average 16 min, while the co-enactments lasted on average 36 min. One reason for this difference was the time allotted for students' group work in the co-enactments. The time spent on TTOs, however, differed in the two settings. In rehearsals, approximately 60% of the time was spent on teaching and 40% on TTOs. In co-enactments, approximately 90% of the time was spent on teaching, not including students' group work, and 10% on TTOs. One reason for this difference might be that the average length of TTOs in the rehearsals (61 sec) was much longer than in the co-enactments, where the TTOs lasted 16 seconds on average.

What Was Addressed in TTOs in Rehearsals and Co-enactments?

We provide an overview of the frequency of occurrence of each of the most salient ambitious practices in the rehearsals and the co-enactments (Table 2). This information is organised according to the percentage of all TTOs that included this practice. The percentage of all TTOs that included a particular practice shows how often this category was worked on across all TTOs. Table 2 shows that the TTOs in the rehearsals focused predominantly on the practices *use of representation* (29%), *aiming towards goals* (25%) and *launching a problem* (23%). The practices *organising the board* (18%) and *facilitating student talk* (16%) occurred less frequently overall (Wæge & Fauskanger, 2021).

In co-enactments, the TTOs focused predominantly on the practice of *eliciting and responding* (39%). This practice was not among the most frequent practices in the rehearsals. The practices *aiming towards goals* (24%) and *use of representations goals* (21%) occurred less frequently in TTOs. We note that almost one third of the TTOs that included work on representations were initiated in one particular co-enactment by one of the groups.

When we focus on the two most salient practices that take place in the TTOs in rehearsals and co-enactments, we find three practices: eliciting and responding, aiming towards a goal, and using representations. We describe and compare how the participants worked on these three practices in the two settings. For each practice, we describe how the TTOs provided opportunities for the teachers to collectively learn the practices and principles of ambitious mathematics teaching and to develop pedagogical judgment. Although we discuss the practices separately, we note that many of the TTOs involved simultaneous work on multiple aspects of practice.

Eliciting and Responding

Eliciting and responding to student thinking was an important focal point in TTOs in co-enactments, but not among the most frequent practices in TTOs in rehearsals.[1] In co-enactments, the participants addressed which questions the teachers could ask to engage the students in mathematical explanations and argumentations and to elicit the details of students' thinking.

Table 1. Patterns of TTO use in rehearsals and co-enactments.

Patterns of TTO use	Rehearsals ($n = 18$)	Co-enactments ($n = 18$)
Average length	16 min	36 min
Number of TTOs	175	166
Average number of TTOs	10	9
% of time spent on teaching	60%	90%
% of time spent on TTOs	40%	10%
Average length per TTO	61 sec	16 sec

Table 2. Frequency of the key practices, per TTO.[a]

Teaching practice	% of all TTOs in rehearsals ($n = 175$)	% of all TTOs in co-enactments ($n = 166$)
Elicit and respond		39
Use of representations	29	21
Aiming towards goals	25	24
Launching a problem	23	
Organising the board	18	
Facilitating student talk	16	

[a]The table only includes the numbers for the most frequent practices.

The participants also considered possible questions the teacher could ask to direct the students towards important mathematical ideas. This is related to the practice of aiming towards a goal, which will be described below. The (few) discussions in the rehearsals that addressed the practice of eliciting concerned this particular aspect, and some of the discussions in the co-enactments were related to these discussions. The example below from a rehearsal and the following co-enactment of a choral count, counting by 4 s starting at 5, illustrates this. The lesson goal was to find different patterns emerging in the count, and to explore the connection between the numbers in the count and the four times table ($4n + 1$), for example by using numerical expressions. We join the rehearsal as one of the students[2] shares his thinking, and the lead teacher (LT) pauses the instruction:

1 Student:	I see that the 9 is 8 plus 1, and 8 is in the four times table. And 13 is 12 plus 1, and 12 is in the four times table. And that continues all the way.
2 LT:	Then it's a little, that it's time out.
3 Teacher1:	How will we find. "Can you make an expression?" Can you [lead teacher] say that? [the discussion continues]. (Session 2, choral counting, group 2, rehearsal)

The lead teacher was not sure how to respond to the student's idea (Line 1) and initiated a TTO (Line 2). This led to a discussion on how the teacher could respond to the student's contribution and what questions he could ask to orient the students towards the lesson goal. One of the observing teachers suggested that the lead teacher could ask the student(s) to make an expression (Line 3). Later in the discussion, another teacher suggested that the teacher could represent the student's thinking on the board to give space for all students to understand his idea. Based on these suggestions, the lead teacher continued the instruction.

In the following co-enactment, some of the exchanges were closely related to the discussions in the rehearsal. We join the co-enactment when one of the students claims that you can get the numbers in the first row (in Figure 2) by taking the four times table and then add one. The lead teacher pauses:

1 LT:	Now we're into something here.
2 The others:	Yeah.
3 LT:	How should we?
4 Teacher1:	I would have said/
5 TE:	Yeah, [use] another word, yeah.
6 Teacher1:	How would you have said what she is saying now, for the number 5 for example. Can it be done? [to ask:] "Can you say the expression?"
7 LT:	We can try. (Session 2, choral counting, group 2, co-enactment)

The lead teacher pointed out that the student contribution, which was similar to the student contribution in the example from the rehearsal, was something they could build on (Line 1), and he asked how to do it (Line 3). One of the teachers suggested that the lead teacher should ask the

[1]In rehearsals, this practice occurred in 13% of the TTOs.
[2]When we refer to "student" in rehearsals, we mean the "teacher" acting as student.

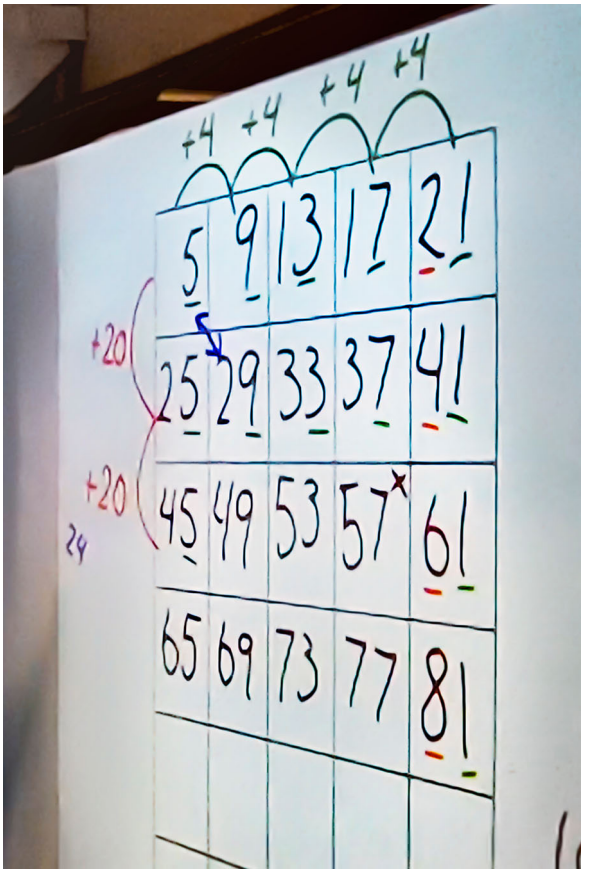

Figure 2. Student count and strategies are represented on the board.

students to make an expression (Line 6) as they discussed in the previous rehearsal. The lead teacher agreed to try it (Line 7) and continued teaching.

The examples above illustrate how TTOs, mostly in the co-enactments, provided opportunities for the teachers to collectively learn how to elicit and respond to students' thinking and to develop pedagogical judgment. The analyses show how the teachers engage in pedagogical reasoning and decision-making in-the-moment of instruction, addressing how to respond to student contributions and what questions the teacher could ask to orient students towards key mathematical ideas.

Moreover, the examples illustrate how the collective considerations in the TTOs are framed around key principles of ambitious teaching: treating students as sense-makers by allowing them to do the thinking and providing all students with equitable access to learning by providing space for students' contributions. The TTOs supported the teachers in developing a shared understanding of the principles of ambitious teaching. The analyses show how the teachers were connecting pedagogical reasoning and pedagogical actions to pedagogical responsibility (Horn, 2020). Because the teachers had planned the lesson together and were working on learning ambitious teaching, the opportunity to pause during instruction gave them the chance to think through and share their reasoning about teacher actions in relation to principles of ambitious teaching. Moreover, their debriefing after the co-enactment provided them with an opportunity to collectively consider what they can gain from the experience. Note that how the participants made sense of these ways of interacting with students during planning and debriefing was critical to their learning experience.

Aiming Towards a Goal

Several TTOs in rehearsals and co-enactments addressed the practice of orienting the students towards the mathematical learning goal for the lesson. This practice is closely related to other practices, such as eliciting and responding, and the teachers worked simultaneously on multiple practices. In rehearsals, the participants discussed how the teacher could use the students' thinking to promote key mathematical ideas. They discussed which strategies she should choose and how to connect different student strategies – and why. They also discussed how the teacher could use visual representations, such as quick images and number lines, to help the students explore patterns and to compare different strategies (Wæge & Fauskanger, 2021). In co-enactments, the TTOs were on many of the same issues, but were often shorter and consisted of specific suggestions for what the teacher might say or do and when to do it (timing), for example: "Can you take that example from the student there [points at the board]", and several of the exchanges on this practice were related to the more elaborate discussions in rehearsals.

This is illustrated in the example below from a rehearsal and the following co-enactment of a quick image. The key mathematical learning goal for students was to learn the distributive property of multiplication ($a \times (b + c) = a \times b + a \times c$). The lead teacher showed a quick image for a few seconds and then asked the students how many dots they saw and if they could explain how they found the answer. Just prior to the TTO, the teacher represented different student strategies on the board, both by writing numerical expressions and by using the quick image (see Figure 3). Note the two strategies $3 \times 5 + 3 \times 4$ and 3×9 that were written on the board.[3] We join the rehearsal as the lead teacher represented the strategy "three times ten minus one" on the board: $3 \times 10-1$. The teacher educator paused the instruction:

1 TE:	But then the idea of using parentheses is interesting [refers to the expression $3 \times 10-1$ on the board].
2 Teacher1:	I was just thinking the same thing. I was thinking that this [the expression] with 3×9 [on the board] is an excellent opportunity to get them [the students] to see $3 \times (5 + 4)$. You [lead teacher] can ask them "Does anyone see 9 in another way?" Then we have 5 and 4, and then you [lead teacher] write down $3 \times (5 + 4)$.
3 LT:	Yes.
…	[The lead teacher writes $3 \times (5 + 4)$ on the board]
25 Teacher1:	And you could have drawn it [$3 \times (5 + 4)$] too. On the [quick image with illustration of 3×9], the 4 and 5 together, like you did before. Most likely few see 4 plus 5 in the parenthesis. That's maybe difficult.
26 LT:	How would you draw it? [the discussion continues]. (Session 3, quick image, group 2, rehearsal)

The teacher educator started to talk about the use of parenthesis (Line 1), but one of the teachers pointed to the strategy 3×9 as something to address. He explained how 3×9 could be used as a starting point to show that $3 \times (5 + 4) = 3 \times 5 + 3 \times 4$, and he illustrated follow-up questions that could help the students to focus on the distributive property (Line 2). This led to a discussion on how the teacher could use the students' strategies to promote their understanding of the distributive property (Lines 4–24). Later in the discussion, one of the teachers pointed out that it might be difficult for students to see the connection between the two expressions (3×9 and $3 \times (5 + 4)$) and suggested that the teacher should show where they find the 4 and the 5 on the quick image representing 3×9 (Line 25). The lead teacher then asked how to illustrate that on the quick image (Line 26). This led to a discussion on how the teacher could use the quick image to connect the two expressions. In the same TTO, the participants also discussed the expression $3 \times 10-1$ (on the board) and how the teacher could proceed and write a parenthesis ($3 \times (10-1)$) so that it was a mathematically correct representation of the student's idea. For example, one participant suggested

[3]In Norway, "·" is used as a multiplication sign. Here we write "×".

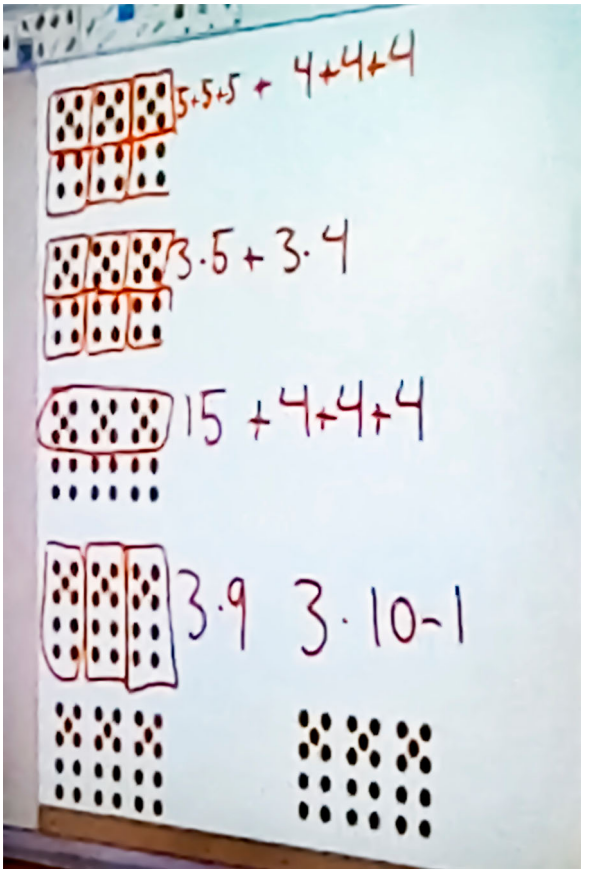

Figure 3. Student strategies for finding the number of dots in a quick image.

that the teacher could write a parenthesis and ask the students if they could think about why she did this.

As illustrated above, the importance of using quick images to support students' understanding and help them see connections between different expressions was highlighted in the rehearsal, and this was also addressed in the following co-enactment. We join the co-enactment, as one of the students has explained the connection between the two expressions $5 \times 3 + 4 \times 3$ and $(5 + 4) \times 3$ (marked in Figure 4). The lead teacher initiates a TTO:

1 LT:	Time out. Yes.
2 TE:	Eh, can … now I have to think too [laughter]. Eh, yeah how do I know it'll be right, how do I know it'll be the same answer?
3 Teacher1:	Can you use the [quick] images?
4 TE:	Can the [quick] images be used to explain why, why we get the same answer in the two expressions? [directs the question to the students] They can discuss with the students on the side. (Session three, quick image, group 2, co-enactment)

The lead teacher asked for help in responding to the student's explanation (Line 1). The teacher educator suggested that the teacher should focus on why the two expressions had the same answer (Line 2). One of the teachers suggested using the quick images to support the students' thinking (Line 3), as they discussed in the previous rehearsal. The teacher educator followed up this suggestion by turning to the students and asking them to use the quick images to explain this (Line 4).

One aspect of the practice of aiming towards a goal was only emphasised in co-enactments, namely closing the discussions. The participants focused on when and how the teacher could close the discussions by summarising where the students were in their thinking and by highlighting or making explicit key mathematical ideas. For example, one of the observing teachers suggested that the lead teacher could make a key idea explicit when closing the discussion on a string "We do the same on both sides, so the answer is the same".

The examples above illustrate how the TTOs in rehearsals and co-enactments worked in complementary ways to provide opportunities for teachers to learn the practice of aiming towards goals and develop pedagogical judgment. In both rehearsals and co-enactments, the participants were negotiating which strategies to select and how to connect different strategies to facilitate students' understanding of mathematical ideas. However, there were some differences in *how* the participants were sharing teacher decision-making in the two settings. The TTOs in rehearsals often consisted of rich considerations of possible teacher strategies and pros and cons of using the strategies. Through asking questions, trying out, giving feedback and having discussions, the participants were trying to figure out which decisions to make and why. In co-enactments, the TTOs often consisted of shorter exchanges or specific suggestions of what the teacher might say or do in the particular situation, sometimes building on the more elaborate collective considerations and pedagogical reasoning in the previous rehearsals.

The examples also illustrate how the teachers' considerations and pedagogical reasoning considered the aspects of mathematics (distributive property), teaching (representation that helps

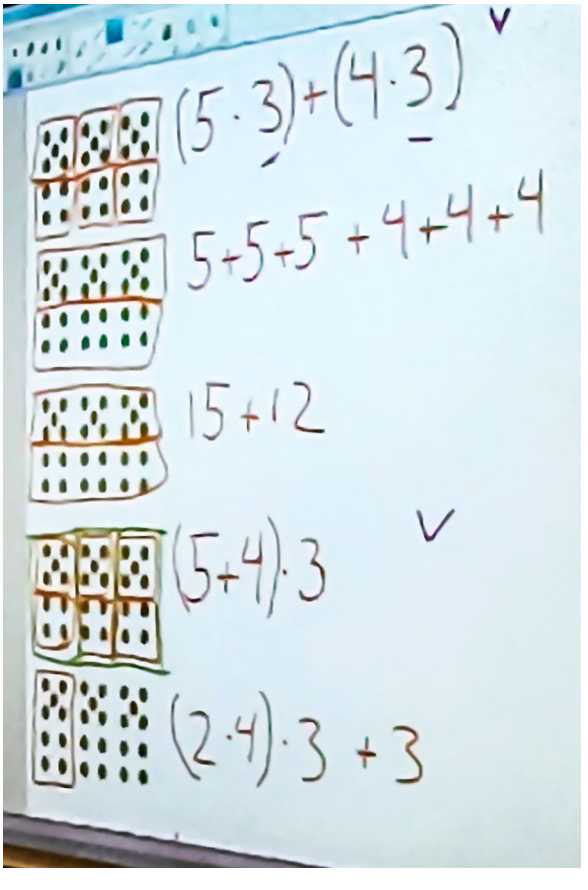

Figure 4. Student strategies for finding the number of dots in a quick image.

students see connections) and students (it could be difficult for students) as interdependent aspects of instruction (Horn, 2020; Lampert, 2001). Similar to the previous examples, this shows how the opportunities to pause during instruction gave the teachers a chance to think through and make sense of decision-making in relation to the principles of ambitious teaching, for example treating students as sense-makers by using student ideas to connect to the lesson goal, and thus building connections across pedagogical action, pedagogical reasoning and pedagogical responsibility.

Use of Representations

Using representations is closely related to other ambitious practices, and the teachers worked simultaneously on several practices. Representing students' mathematical ideas in writing and making connections between student talk and representations and between different kinds of representations were addressed in many TTOs in rehearsals and co-enactments.

In the rehearsals, recording the students' thinking as accurately as possible was emphasised (Wæge & Fauskanger, 2021). This was not frequently addressed in the co-enactments, however, some suggestions in the co-enactments built on the discussions from the rehearsals. The example below, from a rehearsal and the following co-enactment of a string, starting with the task 100 : 4 illustrates this. The context of the first problem in the string was a relay. The total run was one hundred metres, and four students were going to run equally long. One of the students said that "they have to run 25 metres each" because "four times 25 equals one hundred". We join the rehearsal as the teacher represents the student's idea. First, she divides a line segment on the open number line into two equal parts. Then then she divides each of these two parts into two equal parts, thus representing (100 : 2) : 2 instead of 4×25. The teacher educator initiates a TTO:

1 TE:	What is interesting here is that you [the student] have thought, you have explained that you were thinking four times 25. You just knew that, right? But, when you [the teacher] were making the number line now, what did she [the teacher] do [represent on the board], do you recognise that? [she looks at the others]
2 Teacher1:	She [the student] divided into two and then divided into two again.
3 TE:	Yes, you [the teacher] halved and then halved again.
4 LT:	Ok.
5 TE:	It's important that we're aware of this [that this represents (100 : 2) : 2 and not 4×25] [the discussion continues]. (Session six, strings, group 2, rehearsal)

The teacher educator wanted the lead teacher to record exactly what the student was saying (4×25, Lines 1 and 5), and invited the teachers to recognise this (Line1). One of the observing teachers recognised that the teacher had represented (100 : 2) : 2 instead of 4×25 (Line 2). This initiated a discussion on how the lead teacher could represent what the student said. The teacher educator advised the teacher to represent 4×25 as "25 and 25 and 25 and 25" on the number line, showing the four "jumps" by pointing to the number line. They agreed that the lead teacher in the co-enactment should illustrate 4×25 as four jumps of the length 25 and in addition writing 25 above each arch as illustrated in Figure 5.

The following co-enactment has a similar situation and the teacher educator again reminds the lead teacher to represent the student's thinking as accurately as possible. Just prior to the TTO, one of the students said that "I took the first half of 100, and then I took half of 50". We join the co-enactments as the teacher represents the student's idea $(100 : 4 = (100 : 2) : 2$ by drawing "jumps" of 25 on the number line. The teacher educator takes a TTO:

1 TE:	Can I ask for a time out?
2 LT:	Yes.
3 TE:	Can you draw it like the student said?
4 LT:	Yeah, I can, yeah. (Session six, strings, group 2, co-enactment)

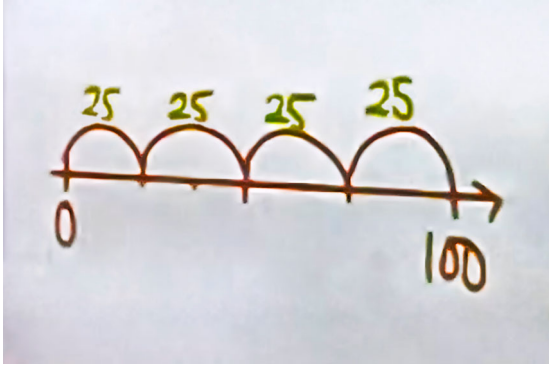

Figure 5. 4×25 represented on a number line.

The teacher educator asked for a TTO (Line 1) and suggested that the lead teacher should represent the student's idea as the student actually said it (100 : 4 as (100 : 2) : 2 instead of 4×25) (Line 1). The teacher agreed (Line 4) and continued instruction by dividing the number line into two equal parts and then divided each of these two parts into halves again. Since they had discussed this issue in a similar situation in the rehearsal, the teacher understood what the teacher educator meant. This example, and others, illustrates how many of the participants' considerations and collective pedagogical reasoning in co-enactments were grounded in the longer and more elaborate discussions in the rehearsal.

Representing and connecting student strategies in-the-moment of teaching is challenging. Our analyses show that the TTOs provided opportunities for teachers to learn this practice collectively. The participants negotiated how to represent students' mathematical ideas in writing and also to represent their ideas as accurately as possible. The analyses show how the participants' collective sensemaking in co-enactments often referred back to the rich considerations and pedagogical reasoning in the rehearsals.

Moreover, our analyses show how the participants' collective sensemaking and reasoning about instruction, pedagogical actions and pedagogical responsibilities were actively being brought together (Horn, 2020). The participants were drawing on the principles of engaging deeply with students' thinking and treating students as sense-makers when negotiating how to represent their thinking. Thus, the analyses show how the teachers were engaged with pedagogical reasoning, as they drew on clear principles of ambitious teaching and adjusted their pedagogical actions.

Discussion

In this article, we have examined the patterns of use of TTOs in rehearsals and co-enactments, and we have explored how the TTOs in the two settings provide complementary opportunities for teachers to learn ambitious mathematics teaching practices and develop pedagogical judgment. Our findings show that there is a back-and-forth pattern between teaching and TTOs in both settings. This helps to draw the teachers' attention more towards principles and practices of ambitious mathematics teaching, and to build explicit connections across pedagogical action, pedagogical reasoning and pedagogical responsibility (Horn, 2020).

Being responsive to students' emergent ideas is one of the most challenging parts of ambitious teaching (Richards & Robertson, 2015), and Kennedy (2016) argues that PD programmes should be designed to support teachers' engagement with in-the-moment instructional decisions. Our study shows how TTOs in rehearsals and co-enactments provided complementary opportunities for teachers to work on complex in-the-moment decision-making and to develop a shared understanding of ambitious teaching that enabled them to use the ambitious practices and principles adaptively in

new situations. The findings indicate that it is important to include both rehearsals and co-enactments in PD programmes that aim to support teachers' learning of ambitious mathematics teaching.

Supporting Responsive Teaching

According to Horn (2020), designing activities that support the development of pedagogical judgment is crucial for teachers' learning of ambitious teaching. Our study indicates that the TTOs in rehearsals and co-enactments supported the teachers' engagement with pedagogical reasoning and decision-making in-the-moment of instruction, and with connecting pedagogical reasoning to pedagogical actions and responsibility. They were settings in which the teachers collectively reasoned about and explored the practices of ambitious teaching and developed a shared sense of pedagogical responsibility. The teachers considered different aspects of practice and offered specific suggestions on what the teacher could do in a particular situation, drawing on key principles of ambitious teaching, such as treating students as sense-makers. Moreover, our study shows that the teachers' pedagogical reasoning considered the three aspects of instruction, namely teaching, students and mathematics, as interrelated aspects of instruction (Horn, 2020; Lampert, 2001), indicating that rehearsals and co-enactments supported their engagement with the complexity of in-the-moment instructional decisions (Richards & Robertson, 2015). The debriefings after the co-enactments allow the teachers to collectively consider what they can gain from the experience, and they might further support the teachers' development of adaptive expertise. In the MAM project, the collective analyses or debriefing have, however, yet to be explored.

Complementary Ways of Working on the Practices

Our findings show that there were some differences regarding *how* the participants shared decision-making in the two settings. The TTOs in rehearsals often consisted of rich collective considerations on possible teacher strategies and moves. Through asking questions, trying things out and providing feedback, the participants figured out what decisions to make and why. In rehearsals, the teachers' pedagogical reasoning and sensemaking sometimes uncovered pedagogical dilemmas, for example, how the teacher could represent the students' thinking as accurately as possible whilst simultaneously considering the mathematical correctness of the representations (Wæge & Fauskanger, 2021). The TTOs in co-enactments, however, consisted of shorter exchanges and specific suggestions as to what the teacher might say or do in the particular situation. This may be related to the fact that students are present in co-enactments and that the teachers already have the shared experience of the co-planning and the rehearsal. The teachers' collective considerations in the co-enactments sometimes built on the more elaborate considerations and pedagogical reasoning in the previous rehearsals. Thus, the TTOs in the two settings worked in complementary ways to support the teachers' learning of ambitious teaching.

Focusing on Different Ambitious Practices in the Two Settings

Our study shows that the teachers tried to make sense of several ambitious practices simultaneously and to see them in relation to each other. However, there were some differences relating to which practices the participants focused on in the two settings. Eliciting and responding was the most frequent practice in TTOs in the co-enactments. This has also been emphasised in co-enactments within Math Labs (Gibbons et al., 2017). Eliciting and responding is also considered to be an important focus in rehearsals with novice teachers (Ghousseini et al., 2015; Lampert et al., 2013) and more experienced teachers (Kavanagh et al., 2020). Our findings from the rehearsals differed, however, from other studies as eliciting and responding was not an important focal point in the TTOs. In our study, the participants mostly worked on this practice in co-enactments.

Aiming towards goals and using representations were among the most salient practices in both rehearsals and co-enactments. For both practices, the participants focused on different aspects in the two settings. For example, recording the students' thinking as accurately as possible was emphasised in the rehearsals (Wæge & Fauskanger, 2021), however, this was not frequently addressed in the co-enactments. We also found that closing discussions were only emphasised in the co-enactments, not in the rehearsals. Thus, the two settings provided opportunities for collective considerations on complementary aspects of the practices of ambitious teaching.

Conclusion and Next Steps

Our study provides insight into how TTOs in rehearsals and co-enactments provided complementary opportunities for teachers to learn ambitious teaching and the complex work of in-the-moment decision-making (Richards & Robertson, 2015). While this study contributes to the knowledge base regarding how teachers can work collectively in rehearsals and co-enactments to explore the complex demands of ambitious teaching, more research is needed. One limitation of this study is that it did not address how the collective debriefing after the co-enactment might help the teachers to consider what they can gain from the experience (Munson et al., 2021), and how it might support their engagement with pedagogical reasoning and their development of adaptive expertise. A next step within MAM will be to explore the other phases of the learning cycles to better understand if and how all elements, such as debriefs, might support teachers' learning of ambitious mathematics teaching and their pedagogical judgment.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

ORCID

Kjersti Wæge http://orcid.org/0000-0002-7303-9008
Janne Fauskanger http://orcid.org/0000-0001-5840-1227

References

Chapman, O. (2016). Approaches and challenges in supporting mathematics teachers' change. *Journal of Mathematics Teacher Education*, *19*(1), 1–5. https://doi.org/10.1007/s10857-016-9342-2

Charalambous, C. Y., & Delaney, S. (2020). Mathematics teaching practices and practice-based pedagogies: A critical review of the literature since 2000. In D. Potari & O. Chapman (Eds.), *International handbook of mathematics teacher education* (Vol. 1, pp. 355–390). Brill.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, *18*(8), 947–967. https://doi.org/10.1016/S0742-051X(02)00053-7

Corbin, J., & Strauss, A. (2008). *Qualitative research*. Sage Publications.

Fauskanger, J. (2019). Ambisiøse undervisningspraksiser i Teacher Time Out [Ambitious teaching practices in Teacher Time Out]. *Nordic Studies in Mathematics Education*, *24*(1), 75–94.

Ghousseini, H., Beasley, H., & Lord, S. (2015). Investigating the potential of guided practice with an enactment tool for supporting adaptive performance. *Journal of the Learning Sciences*, *24*(3), 461–497. https://doi.org/10.1080/10508406.2015.1057339

Ghousseini, H. N. (2021). The work of coaching in rehearsals to enlist mathematical knowledge for teaching. In Y. Li, R. E. Hove, W. J. Lewis, & J. J. Madden (Eds.), *Developing mathematical proficiency for elementary instruction* (pp. 165–181). Springer. https://doi.org/10.1007/978-3-030-68956-8_7

Gibbons, L. K., Kazemi, E., Hintz, A., & Hartmann, E. (2017). Teacher time out: Educators learning together in and through practice. *NCSM Journal of Mathematics Education Leadership*, *18*(2), 28–46. https://tedd.org/wp-content/uploads/2017/05/JMEL-2017-Teacher-Time-Out.pdf

Grossman, P., Kavanagh, S. S., & Dean, C. G. P. (2018). The turn towards practice in teacher education. In P. Grossman (Ed.), *Teaching core practices in teacher education* (pp. 1–14). Harvard Education Press.

Hoover, M., Mosvold, R., Ball, D. L., & Lai, Y. (2016). Making progress on mathematical knowledge for teaching. *The Mathematics Enthusiast*, *13*(1), 3–34. https://doi.org/10.54870/1551-3440.1363

Horn, I. S. (2020). Supporting the development of pedagogical judgement. Connecting instruction to contexts through classroom video with experienced mathematics teachers. In G. M. Lloyd & O. Chapman (Eds.), *International handbook of mathematics teacher education* (Vol. 3, pp. 321–342). Brill. https://doi.org/10.1163/9789004419230_013

Kavanagh, S. S., Metz, M., Hauser, M., Fogo, B., Taylor, M. W., & Carlson, J. (2020). Practicing responsiveness: Using approximations of teaching to develop teachers' responsiveness to students' ideas. *Journal of Teacher Education*, *71*(1), 94–107. https://doi.org/10.1177/0022487119841884

Kazemi, E. (2017). Teaching a mathematics methods course: Understanding learning from a situative perspective. In S. Kastberg, A. Tyminski, A. Lischka, & W. Sanchez (Eds.), *Building support for scholarly practices in mathematics methods* (pp. 49–65). Information Age.

Kazemi, E., Ghousseini, H., Cunard, A., & Turrou, A. C. (2016). Getting inside rehearsals: Insights from teacher educators to support work on complex practice. *Journal of Teacher Education*, *67*(1), 18–31. https://doi.org/10.1177/0022487115615191

Kazemi, E., Gibbons, L., Lewis, R., Fox, A., Hintz, A., Kelley-Petersen, M., Cunard, A., Lomax, K., Lenges, A., & Balf, R. (2018, Spring). Math labs: Teachers, teacher educators, and school leaders learning together with and from their own students. *NCTM Journal of Mathematics Educational Leadership*, *19*(1), 23–36.

Kennedy, M. (2016). How does professional development improve teaching? *Review of Educational Research*, *86*(4), 945–980. https://doi.org/10.3102/0034654315626800

Lampert, M. (2001). *Teaching problems and the problems of teaching*. Yale University Press.

Lampert, M., Franke, M. L., Kazemi, E., Ghousseini, H., Turrou, A. C., Beasley, H., Cunard, A., & Crowe, K. (2013). Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching. *Journal of Teacher Education*, *64*(3), 226–243. https://doi.org/10.1177/0022487112473837

Lave, J. (1991). Situating learning in communities of practice. In L. Resnick, J. Levine, & S. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 63–82). American Psychological Association. https://doi.org/10.1037/10096-003

Munson, J., Baldinger, E. E., & Larison, S. (2021). What if … ? Exploring thought experiments and non-rehearsing teachers' development of adaptive expertise in rehearsal debriefs. *Teaching and Teacher Education*, *97*, 103222. https://doi.org/10.1016/j.tate.2020.103222

Richards, J., & Robertson, A. D. (2015). A review of the research on responsive teaching in science and mathematics. In A. D. Robertson, R. E. Sherr, & D. Hammer (Eds.), *Responsive teaching in science and mathematics* (pp. 36–55). Routledge.

Shaughnessy, M., Ghousseini, H., Kazemi, E., Franke, M., Kelley-Petersen, M., & Hartmann, E. S. (2019). An investigation of supporting teacher learning in the context of a common decomposition for leading mathematics discussions. *Teaching and Teacher Education*, *80*, 167–179. https://doi.org/10.1016/j.tate.2019.01.008

Valenta, A., & Wæge, K. (2017). Rehearsals in work with in-service mathematics teachers. In T. Dooley & G. Gueudet (Eds.), *Proceeding of the tenth Congress of the European society for research in mathematics education* (pp. 3881–3888). Dublin City University and ERME.

Wæge, K., & Fauskanger, J. (2021). Teacher time outs in rehearsals: In-service teachers learning ambitious mathematics teaching practices. *Journal of Mathematics Teacher Education*, *24*(6), 563–586. https://doi.org/10.1007/s10857-020-09474-0