Mediating mathematics out of the lesson: Tamra’s personal breaching experiment

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Research on how teachers’ instructional choices are framed by professional obligations provides insight into the processes of decision-making. This is particularly pertinent when a teacher sets out to change her teaching. An understanding of these processes can inform support for teachers as well as teacher education. This paper reports on a lesson in which Tamra – for the first time – is trying out a more explorative approach with her Grade 7 learners. Tensions prevail between the obligation on Tamra to attend to individual learners, the national curriculum goals, institutional goals, and enabling mathematical exploration. Tamra’s choices ultimately mean that the obligation to mathematics suffers, yet they reflect a relevant practical rationality.

## Introduction: the teacher as a dilemma manager

Teachers make decisions, and decisions are informed by weighing up alternatives based on a range of factors. Previous research on teacher decision may be grouped, I suggest, into four non-disjunctive categories of factors informing the decisions. One group of studies focuses on teachers’ beliefs and knowledge; for instance, Blackley et al., 2021 studied the relationship between experiences of affect, cognitive load, and awareness of available options. Another group of studies focuses on teacher noticing; for example, participating in a video club on noticing increased teachers’ ability to use what they noticed about learner thinking to inform decisions (Wallin & Amador, 2019). A more recent group of studies concerns norms and patterns of participation established from previous experiences such as own schooling or teacher education; for example, the teacher education of two student teachers did not challenge their patterns of participation from earlier schooling (Ebbelind, 2020). Finally, a group of studies has engaged the obligations that exercise a pull on teachers, which may manifest as different and not always compatible goals for teachers: Thomas and Yoon (2014) describe how a teacher resolves conflicts between goals and the relation to the decisions the teacher makes. The teacher’s “conflict between … two goals was largely caused by the constraints of time, curriculum, and assessment, but also his desire to respect the cultural influences on his students’ learning” (p. 232). Thus, the last group of studies hone more in on the practical rationality (see below) of teachers and how it plays out within the opportunities and constraints of their classrooms, regarding decisions to be shaped as much by institutional factors as by personal ones. Considering external factors is important for understanding why teachers make decisions that appear to go against their proclaimed views, and thereby the process of making changes to teaching practices. Managing external factors, the teacher is a “dilemma manager, a broker of contradictory interests” (Lampert, 1985), or in the terminology of practical rationality, a broker of professional obligations which may not pull in the same direction (Herbst & Chazan, 2011).

The experienced external demands and professional obligations of teachers affect the choices they make in their teaching. In a medium-scale study of university mathematics instructors, professional obligations helped explain misalignment between beliefs and practices (Shultz, 2022). Case studies of teachers from different contexts suggested that teachers may choose not to address a mathematically rich response from a learner out of consideration for the classroom community or may reduce learner agency to reach closure by the end of the lesson (Christiansen et al., 2023). And responses to a breaching experiment with 360 secondary mathematics teachers indicated that their willingness to break norms depended on both the norm and the professional obligations at stake (Erickson et al., 2021). When norms are broken, teachers can engage in negotiation of the didactical contracts that apply to the new situation, or they can default to a known instructional situation (Herbst & Chazan, 2012).

As the case discussed in this paper demonstrates, unpacking a negotiation of norms in light of the constraints on a teacher trying to change their practice, provides insights which ultimately may be brought to work in assisting or preparing teachers to handle these complex processes. The research question guiding the study is: *In which implicit negotiations of professional obligations does a teacher engage when she attempts to implement an exploration-requiring activity?*

The teacher in the study, Tamra, wants to change her teaching towards engaging learners in exploration activity, and the lesson analysed is her first attempt at doing so. However, as the lesson progresses, Tamra moves away from the exploration activity. To understand why, interviews with Tamra were analysed for indications of professional obligations and potential tensions between them.

## Frameworks

Two theoretical perspectives have been utilised in this study: (i) for the analysis of Tamra’s classroom teaching, I have drawn on notions within the theory of commognition; (ii) the reasons for Tamra’s choices were investigated drawing on the notion of professional obligations.

In the commognitive theoretisation of Anna Sfard (e.g., 2008; 2016), one component of the mathematical discourse is routines. Explorations are discursive routines that lead to the production of substantiated narratives (Lavie et al., 2019). Rituals, on the other hand consist largely of “imitating someone else’s former performance” (Nachlieli & Tabach, 2019, p. 255) “for the sake of social rewards or in an attempt to avoid a punishment” (Lavie et al., 2019, p. 166).

What is a ritual to one learner, may be an exploration to another, though an observer is unable to tell the difference (Lavie et al., 2019). This makes the concepts inapplicable for analysing classroom activities, and in particular for analysing teaching. Instead, the *opportunities to learn* (OTL) – to engage in rituals or explorations made available through the teaching – can be considered, Nachlieli and Tabach (2019) suggest. Since learners may choose to engage in an exploration even if the relevant part of the lesson invites a ritual, Nachlieli and Tabach refer to such situations as *ritual-enabling OTLs*, defined as “teachers’ actions that provide students with tasks that could be successfully performed by rigid application of a procedure that had been previously learned.” (Nachlieli & Tabach, 2019, p. 257). If, on the other hand, learners are not provided with a ritual to imitate, the lesson would require them to engage in an exploration, wherefore it is referred to as an *exploration-requiring OTL*, defined as “teachers’ actions that provide students with tasks that could not be successfully solved by performing a ritual” (Nachlieli & Tabach, 2019, p. 257).

Learners often have to learn a routine as a ritual and gradually move from imitating the routine to focusing on how to reach the desired outcome, that is, treating the routine as a narrative; this process is referred to as deritualisation (Lavie et al., 2019, in passim). This shift in discourse happens when learners take part in the discourse while exerting effort to shift attention to the outcomes of the routine (Sfard, 2020). Deritualisation is characterised by increased flexibility, bondedness, applicability, performer agentivity, objectification, and substantiability (Lavie et al., 2018).

In the analysis of Tamra’s lesson, I focused on the three latter of the characteristics of deritualisation, from a teaching perspective. This means that instead of focusing on the characteristics of deritualisation evident in the discourse of the learners, I analysed Tamra’s interactions with the learners for invitations for learner agentivity and substantiability, as well as the extent to which her discourse utilised mathematical objects. This allowed me to determine the extent to which Tamra implemented an exploration-requiring OTL (see Christiansen et al., 2023 for details on this approach).

The analysis of Tamra’s lesson served as a backdrop for identifying the choices she made as the lesson progressed and what informed them. For this purpose, interviews with Tamra were analysed for references to professional obligations. Professional obligations are generated by the “hold of the environment on the position of the teacher” and Herbst and Chazan (2011; 2012) categorise these according to their source: the individual learner, the socio-cultural world, the institution, and the discipline. The obligations shape the teacher–learner relationship and operate on the norms of the teaching.

The teacher–learner relationship exists because the learners must acquire knowledge which the teacher has (or, within a participatory view on learning, because the learners are expected to increase their participation in the discourse of which the teacher is a more adept participant). But since this learning may not happen, the knowledge is “at stake” (Herbst & Chazan, 2011; 2012). The teacher must enable learners’ mathematical work that can be “exchanged” for the knowledge at stake. Often, a particular norm has been established for the mathematics teaching in each classroom, and changing this norm requires renewed negotiation of practices and relationships. However, it is also subject to the constraints of the institution, the curriculum, and mathematics itself. Therefore, negotiating the norms of the classroom takes place not just between teacher and learners but in relation to the professional obligations.

Obligations linked to *individual* learners can, for instance, be to consider the unique strengths and needs of each learner, even as these are represented by their legal guardians (Herbst & Chazan, 2012; Schultz, 2022). The teacher is also expected to represent the *discipline* as it is understood in the institutions of society. Teaching is always taking place within a broader socio-cultural context with values, norms, and practices, and this constitutes *interpersonal* obligations to create a socio-culturally appropriate classroom environment (Herbst & Chazan, 2012; Schultz, 2022). Finally, there are *institutional* obligations on teachers from curricula, policies, school rules, etc., which include fixed lesson times, rules about use of space, and so forth.

## Methods

Tamra is a participant in the Swedish TRACE project which follows novice mathematics teachers in the first years of their profession. In the project, eleven of her lessons were video-recorded, starting from two lessons during her teaching practice in 2018, and biannually with a one-year interruption due to Covid-19 restrictions, until May of 2022. Five interviews with Tamra were conducted: one about her impressions of her teacher education, three about a sequence of lessons observed, and one looking back over the period and her development. Lessons were video-recorded with a focus on Tamra’s, not learners’ activity, and interviews were audio-recorded. This study discusses Tamra’s first experiment with an exploration-enabling OTL, a lesson on prime numbers.

For this study, I conducted two analyses. The first analysis was of the lesson, and it allowed me to identify that the lesson moved from offering exploration-requiring OTLs, in line with Tamra’s intentions, to offering ritual-enabling OTLs. The lesson was first divided into units of analysis, where each unit started with the initiation of a task by the teacher and ending with the closing of the task (following Nachlieli & Tabach, 2019). Within these units, Tamra’s utterances were coded for three indicators of exploration-enabling versus ritual-enabling OTLs (following Christiansen et al., 2023). Because she generally referred to mathematical objects in her discourse, the analysis here focuses on the extent to which Tamra invited learner agentivity and learner substantiations.

I coded for overtures for learner agency by the openness of the teacher’s questions and invites for participation to learners (see also Sfard, 2016). Invitations for substantiations were coded by whether Tamra encouraged learners to reproduce substantiations or follow steps of a procedure, alternatively encouraged them to generate their own substantiations. Frequent overtures for learner agentivity combined with encouragement of learners’ own substantiations were seen as indicative of exploration-requiring OTLs, while the opposite codes were seen as indicative of ritual-enabling OTLs (Christiansen et al., 2023 discuss hybrids between these extremes).

The second analysis was a content analysis of the interviews with Tamra, identifying references to professional obligations. Since obligations are characterised as a “hold of the environment on the position of the teacher”, I used content analysis to identify instances where Tamra referred to factors restricting her teaching in any way. Next, I coded these obligations with reference to (a) individual learners or their parents, (b) the class environment, (c) mathematics, (d) institutional factors such as the curriculum, lesson time, or school rules, and (e) other. I also noted when Tamra referred to norms or beliefs she had to confront or change in the process of adjusting her teaching.

In this paper, I focus on the obligations Tamra experienced, but I relate these to how the lesson progressed. Therefore, the next section presents the lesson and my analysis thereof, as a backdrop to the results section.

## Tamra’s lesson on prime numbers

When asked what she wanted to achieve with the lesson, Tamra said that she wanted learners to identify prime numbers (a new mathematical object used in an exploration), factorise (a new routine), use divisibility rules (utilise previous routines in explorations), cement concepts of even and odd, and use the even/odd distinction in checking for divisibility (utilise previous routines).

The lesson had three distinct parts, as well as an almost eleven-minute period spent on organising groups, about which Tamra later expressed frustration. The first part of the lesson was organised as whole-class teaching, with Tamra stating the definition of prime numbers after which learners identified small prime numbers by inspection. The second part of the lesson was also whole-class teaching, where the teacher guided learners through factorisations of 24. The last 19 minutes of the lesson constituted the announced exploration, and my analysis confirmed that it started out as an exploration-requiring OTL. “Can you find factors?”, Tamra asked repeatedly[[1]](#footnote-1). There is no indication that she wanted learners to follow a particular procedure.

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| **Time** | **Focus** | **Overtures for learner agency** | **Invited substantiations** |
| 02:02–09:41 | Whole-class interaction, with learners being tasked with identifying whether 2, 3, 4, 5, … 10 are prime or composite.  At the end of this part, Tamra refers to previously learned rules for divisibility. | Open and closed questions interspersed. | Learners are asked to explain their answers. |
| 09:42–14:44 | Learners are asked to identify whether 24 is prime or composite, but because learners suggest different initial factorisations (4x6, 2x12, 3x8), this evolves into three subroutines of factorising and a question about similarities between factorisations. | Open and closed questions interspersed. | Learners are asked to explain their answers. |
| 14:45–25:29 | Dividing learners into groups and distributing paper and coloured pens. | None. | None. |
| 25:30–44:30 | Learners work in groups deciding whether the natural numbers in different intervals (e.g., 200–250) are odd, even, prime, and/or composite. The class gets rowdy and has to be calmed before the nine-minute report back at the end of the lesson. | First few questions are open, the remainder closed. | First invitations are for learners’ substantiations, the remainer requests to follow Tamra’s procedure. |

Table 1: Tamra’s lesson on prime numbers and coding of overtures for learner agency (open/closed) and invited substantiations (learner generated/given).

Shortly after the groups started to work, while Tamra circulated, the lesson took a turn. In one group, Tamra engaged the learners as she had previously in the lesson: “Are there two numbers we can multiply to get thirteen?” However, the next group she approached was exploring larger numbers, and Tamra instead asked whether the number in question at the time could be divided by 2, 3, or 5. She also used this to identify an even number which the learners had categorised as prime. She used the same strategy with the next group she visited, where learners were struggling to categorise 151. She did not go back to asking the more open question – whether learners could find factors.

The routine of checking for divisibility by 2, 3, and 5 replaced the previous approach of inspection by recognition (which failed the learners working with numbers larger than 100 and learners who did not recognise products from the multiplication tables below 100). In the report-back session from the groups, Tamra verified or rejected the prime numbers suggested by learners only by inspecting for divisibility by 2, 3, and 5.

Insisting on a particular procedure, taking control over when the task is complete, and using closed questions, changed the situation from an exploration-requiring to a ritual-enabling OTL. It is easy to find fault with Tamra’s actions, her decision to take control over the choice of procedure and the closing conditions of the task. However,

we could think of ‘error’ in instruction—really teaching that deviates from what might be deemed desirable—not as an indication of misfit, ill will, or lack of knowledge, on the part of the practitioner. Rather, we should think of this ‘error’ as an indication of the possible presence of some knowledge, knowledge of what to do, which is subject to a practical rationality that justifies it. (Herbst & Chazan, 2011, pp. 428–9)

What made Tamra change the exploration in which she had so wanted the learners to engage? To answer this, I turn to the results of my analysis of the interviews with Tamra.

## Results: Obligations experienced by Tamra

The view on learners and mathematics teaching which Tamra said dominates at her school is to focus on the “weaker” learners, reduce the number of at-risk learners, and give everyone the opportunity to pass. This is in line with the expectations on teachers in Sweden generally, and so was coded as an *interpersonal* obligation. It is not unrelated to the socio-economic context of the school – Tamra deals with learners who have given up on school, learners with challenging home situations, and even drug abuse.

Tamra also talks about the pressure she feels from some parents to pay special attention to their child and help the child achieve well. This obligation towards *individual* learners, and in particular those who are identified as at-risk, creates tensions for Tamra when it meets the *institutional* obligation to teach to and “cover” the curriculum. When asked about the challenges she experiences, she starts listing these:

Tamra: To adapt the teaching so that it suits and reaches everyone. With which pacing must I teach that fits with the content and plan of the curriculum? The greatest challenges so far have been how I can engage learners with drug problems and for whom school has no importance; I still work on that to help the learners.

Tamra wants the learners to engage in an exploration leading to separating positive integers below 250 into prime and composite numbers (an obligation to *mathematics*). At the same time, she is under obligation, from the curriculum (*institutional*), to ensure that each learner can utilise the divisibility rules for 2, 3, 4, 5, 6, 8, 9, and 10 which they have learned in a previous lesson, and she expects the learners to bring that into play in the exploration. However, this was not made clear to the learners; there was no negotiation of task in this – for Tamra and her learners – novel organisation of the classroom activity. At the same time, the disallowance of calculators may facilitate the relevance of using divisibility rules, but it makes it harder for learners to quickly test a hypothesis about a number – such as whether 151 is divisible by seven or not.

Retrospectively, Tamra acknowledges that the many learning objectives for the lesson were counterproductive, particularly for a class where many learners dislike or have given up on mathematics (obligations to the *individual*).

Tamra: The thought was that maybe they can cement their knowledge about even and odd numbers and that [the exploration] could help them apply divisibility rules. But it was too much for such a group, which contains many [learners] who do not have strong foundations in their mathematics and have short concentration spans.

Tamra had 45 minutes for the lesson. She needed to first introduce the definition of prime and composite numbers and ensure that learners understood. In this process, she got into different factorisations of 24, and an extended period of time was spent organising the group work. The group work progressed very slowly, and because Tamra wanted a report-back/sharing phase at the end, only 10 minutes were left for the exploration which she had declared to be the main focus. The time frame is part of the *institutional* obligation to which Tamra must adhere. Yet she addressed different ways of factorising because she wanted to pick up on learners’ questions.

Tamra: I did it just because [different factorisations] occurred to the learners, as I have an ability to make spontaneous changes during the time of the lesson based on what learners ask, and sometimes their questions awaken ideas which lead to a better result.

This is one way in which Tamra handles the *interpersonal* obligation towards ensuring fruitful conversations with and between learners; but in this case, it is at tension with the institutional obligation to complete the lesson within 45 minutes, because tomorrow’s lesson must be about something else – as Tamra laments after the lesson. In a way, Tamra’s norm of adjusting the lesson when constructive opportunities arise for engaging a mathematical narrative beyond the lesson objectives (here the fundamental theorem of arithmetic) clashes with her intention of giving learners time for exploration. It is hence no wonder she chooses to “*default to an instructional situation*, namely by framing the exchange according to norms that have framed other exchanges” (Herbst & Chazan, 2012, p. 606) – in this case by introducing a procedure.

## Discussion

Tamra had two main objectives for the lesson – to engage learners in an exploration of the mathematical objects of prime and composite numbers, and that they should do so using previously introduced routines for checking divisibility. It appears that mathematics is sacrificed to carry the lesson through to completion, in two ways. First, the exploration-requiring OTL is transformed into a ritual-enabling OTL, reflecting a particular way for learners to engage mathematically. Second, the procedure of checking for divisibility of only 2, 3, and 5 has the potential to generate incorrect categorisation of composite numbers as prime (though it does not happen in the lesson).

In the paper, I tried to unpack Tamra’s reasons for her instructional choices in the lesson using the lens of professional rationality. The two objectives are not in themselves in conflict. However, they become so – as in the study of Thomas and Yoon (2014) –because of the institutional constraints of time, together with the obligation to individual learners and the interpersonal obligations of not letting learners fail. Through identifying the obligations that reflect “the hold of the environment” on Tamra as a teacher, I have aimed to map the borders of the space in which she can exercise her rationality. My analysis shows how Tamra’s own views and efficacy, the long-term desired outcomes of teaching vis-à-vis the curriculum, the learners, and the institutional routines create tensions which inform the choices Tamra could and did make. This is in line with previous research. What is unique about Tamra’s case, however, is that she is an early career teacher deliberately trying to change her teaching.

The lesson can be seen not just as a didactical situation between Tamra and her learners in a particular instance of space and time, but as part of Tamra’s journey to develop her teaching. While Tamra’s norms for teaching are still being established, the lesson constitutes a personal breaching experiment (the idea of which is often ascribed to Garfinkel, e.g., 1964). By immersing herself in an instance of a practice that alters her usual teaching, she provides herself – and the research team – with an opportunity to see how she repairs the breaches with the norms she deliberately makes.

As shown above, when confronted with tensions, Tamra chooses to default to a more ritual-enabling OTL. She started by explaining to learners that this was going to be a different lesson, but as this description does not clarify the different activity expected from learners, it does not constitute a negotiation of the didactical contract, as proposed by Herbst and Chazan (2012). In the interview about the lesson, Tamra feels that her instructions to learners should have been clearer, but this does not capture the difference between explorative and ritual routines:

Tamra: I think that we teachers choose and through the choices we determine what the classroom environment becomes. [...]So the instruction was lacking a bit, my instructions to them, besides that it was, no, more was needed, it should have been well planned, it wasn’t well planned. It was planned but not really thought-through planned.

Still, Tamra does not just see this as her shortcoming; she is aware of the expectations, the hold of the environment, on her. In her own words, she must be a mathematics teacher, a special needs teacher, a psychologist, and a researcher/practice developer.

What can the case offer mathematics education research, teachers, and teacher educators? It reminds researchers to keep in mind the constraints under which teachers operate and illustrates the relevance of the notion of practical rationality in doing so. Did she indeed sacrifice the mathematics? Is that the best way to describe her choice? Or did she make a choice which enabled her to “repair” the deviation both from her normal practice and from her intended lesson, so that she could draw the lesson to a close, sufficiently cover a part of the curriculum, and leave the majority of the learners with some – even if incomplete – idea of what prime numbers are and how to identify them? After all, there is a day after this one, and a year after this one, in which it is up to Tamra – and her learners – to correct, adjust, and expand concepts; and in which Tamra can work to correct, adjust, and expand her teaching.

Teachers and teacher educators can utilise the discursive concepts of commognition to more precisely describe different opportunities to learn and what this means to the activity expected from learners. Together with the notion of the didactical contract and negotiation of the same, this becomes more than an analytical tool, it becomes a practical tool to utilise when wanting to implement exploration-enabling OTLs. Instead of despairing at the discrepancy between visions of good teaching and practice, defaulting to deliberately chosen aspects of instructional situations and negotiation of the didactical contract can move practice in desired directions. An awareness of the professional obligations which positions the teacher as a broker may assist in conscious decision-making. And knowledge of the dimensions of deritualisation and related teaching move can guide the negotiations of the didactical contract as well as inform instructional choices. There is much for teacher education to work with here.

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1. All quotes from the lesson and the interviews were transcribed in Swedish and translated by me. [↑](#footnote-ref-1)