

Learning Through Collaboration: Mathematics Teacher Educators and Mentor Teachers in Teacher Education

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Teaching to teach mathematics in a mathematics methods course integrating a school-based practicum experience often involves limited coordination between mathematics teacher educators (MTEs) and mentor teachers (MTs), leading to fragmented supervision and conflicting approaches. This study examines how collaboration between MTEs and MTs in Uruguay supports the professional learning of both groups of teacher educators. Grounded in the framework of boundary learning, we conceptualised their interactions as boundary encounters and analysed five recorded meetings in which MTEs and MTs discussed how to accompany two prospective teachers (PTs) during their practicum. Using a qualitative, exploratory case study design, we traced how the learning mechanisms of identification, coordination, reflection, and transformation emerged in their discussions. Findings show that initial tensions were reframed through the identification of sociocultural differences and pedagogical roles, while coordination developed around boundary objects such as lesson plans and observation tools. Reflection occurred when participants problematised assumptions and adopted others' perspectives, and transformation was evident in proposals for hybrid practices such as joint planning, co-teaching, and shared examination panels. The study demonstrates that collaboration transforms tensions into opportunities and highlights the importance of creating structured spaces for dialogue as well as formally recognising MTs as co-educators in mathematics teacher education.

Keywords • mathematics teacher education research • mentor teachers • boundary learning • professional collaboration • preservice teacher practicum

Introduction

A common challenge in mathematics teacher education is the lack of coordination between mathematics teacher educators (MTEs) and mentor teachers (MTs), particularly in the supervision of prospective teachers (PTs) during their school-based practice (Clarke & Jarvis-Selinger, 2005; Fernandez & Erbilgin, 2009). This disconnect often leads to fragmented and inefficient supervision, which can result in divergent educational models and evaluation methods that undermine the coherence of the entire program (Butler & Cuenca, 2012; Clarke et al., 2014).

Prior studies highlight three recurrent difficulties, namely conflicting pedagogical approaches, predominantly evaluative feedback, and insufficient preparation for the mentoring role. Observational analyses show that MTs often rely on trial-and-error strategies that contrast with the didactic orientations advocated by MTEs (Clarke & Jarvis-Selinger, 2005), and their feedback tends to be evaluative rather than reflective, thereby restricting the opportunities for PTs to critically analyse their practice (Fernandez & Erbilgin, 2009). Building on these findings, research distinguishes different supervision styles and underscores the value of models that move beyond evaluation to privilege dialogue and reflection (Clarke et al., 2014; Tok, 2012). A consistent conclusion is that MTs frequently lack systematic preparation for their role, which reduces their capacity to provide constructive guidance and points to the need for structured professional development (Butler & Cuenca, 2012;



Lafferty, 2018). Furthermore, studies on MTs and university collaboration describe three types of participation: closed, where universities impose roles and expectations; invited, where roles are collaboratively negotiated; and claimed, where MTs define their own functions (Clarke et al., 2014). Of these, invited spaces emerge as the most productive and generative for MTs participation.

Meanwhile, MTEs, in their role as university supervisors, play a crucial and evolving part in the pre-professional teaching practice of PTs, acting as a vital link between university theory and classroom reality. Research indicates that supervisors also serve both as mentors and facilitators, helping PTs make sense of their experiences by mediating between theory and practice. Studies have shown that post-observation feedback from supervisors significantly improved PTs' instructional styles, including their classroom management, communication, and knowledge of curriculum implementation (Boadi et al., 2024; Burns et al., 2016). However, tensions persist within the supervisory dyad: MTEs often adopt a theoretical and didactic stance, while MTs emphasise pragmatic classroom concerns (Fernandez & Erbilgin, 2009). Clarifying responsibilities and ensuring systematic preparation for MTs emerge as conditions for a more constructive supervisory process (Lafferty, 2018).

From a broader perspective, these tensions can be understood as sociocultural differences that may generate discontinuities in boundary crossing between professional communities (Wenger, 2008). In this vein, research on boundary learning has identified four mechanisms through which such encounters can become productive: identification, coordination, reflection, and transformation (Akkerman & Bakker, 2011; Bronkhorst & Akkerman, 2016). International evidence indicates that successful collaboration requires specific enabling conditions, such as mutual trust, respect, and the identification of a shared problem, whereas structural separation and cultural differences often act as barriers (Goos, 2015). At the same time, research on boundary learning shows that such encounters can become generative spaces in which tensions operate not only as challenges but also as resources for developing new hybrid practices (Akkerman & Bakker, 2011; Bronkhorst & Akkerman, 2016).

Despite the relevance of this discussion, empirical studies on MTE–MT collaboration remain scarce in Latin America, and particularly in Uruguay. This gap is significant because institutional arrangements, professional identities, and cultural traditions shape how boundary encounters unfold and what learning opportunities they afford (Akkerman & Bakker, 2011). Addressing this blind spot requires documenting how collaboration is enacted in such contexts and analysing its potential to activate mechanisms of professional learning for both MTEs and MTs.

Building on these considerations, the present study examines the collaborative work between MTEs and MTs in Uruguay as they accompany PTs during their school-based practicum. The aim of the study is to explore how boundary learning mechanisms emerge within this collaborative work as MTEs and MTs engage in the supervision of PTs. Accordingly, the research question guiding the study is: How are boundary learning mechanisms enacted in collaborative encounters between MTEs and MTs regarding the supervision of PTs? By analysing a context that is underrepresented in the international literature, the study expands the empirical base on MTE–MT collaboration and provides insights into the conditions under which such work can enhance the coherence and quality of mathematics teacher education.

Theoretical Framework

In this study, MTEs and MTs are conceptualised as members of two distinct yet related Communities of Practice (CoP), which are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly (Wenger, 2008). This construct is fundamentally characterised by three dimensions: mutual engagement, where members build relationships through regular interaction; a joint enterprise, defined by a shared area of concern and mutual accountability; and a shared repertoire of resources, tools, and stories developed over time (Wenger, 2008).

In the context of this research, the relationship between MTEs and MTs is understood as a social configuration where learning emerges through active participation in a joint enterprise (Wenger, 2008): the professional education of PTs during their school-based practicum. In this regard, as Goos (2014)



argued, “a community of practice perspective is suggested as a means of examining learning through ‘boundary encounters’ between communities” (p. 441). Building on this perspective, this study focuses on the collaborative work of MTEs and MTs in supporting PTs, drawing on boundary learning mechanisms to analyse how such interactions unfold. In what follows, we outline the key concepts that underpin this framework.

Collaborative Work at Boundary Encounters

Collaborative work among teachers has been described as a process that “involves teachers in joint activity, common purpose, critical dialogue and inquiry, and mutual support in addressing issues that challenge them professionally. It helps them in reflecting on their role in school and in society” (Robutti et al., 2016, p. 652). This definition highlights that collaboration goes beyond the division of tasks, involving a process of collective construction that fosters critical reflection and the redefinition of the teaching role.

To understand the interactions between MTEs and MTs, it is helpful to draw on the notion of boundary encounters, which occur when members of different communities interact around a practice and negotiate meanings both within each community and across the boundary that separates them (Butler et al., 2019; Marshman & Goos, 2025; Wenger, 2008). In this study, we focus on the delegation type of boundary encounter, which involves a group of representatives from each CoP and in which negotiation of meaning unfolds simultaneously (Wenger, 2008). These encounters are often organised around boundary objects, understood as artefacts that mediate between communities because they are simultaneously adapted to local needs and retain a recognisable identity that sustains shared understanding (Star & Griesemer, 1989). For example, a practicum observation protocol used jointly by MTE and MT can function as a boundary object, as it structures what each one attends to during a PT’s lesson while allowing each community to interpret and use it according to its own professional perspectives. In this sense, the function of a boundary object is to bring together and relate diverse perspectives, so that their meaning emerges precisely at the intersection of viewpoints (Wenger, 2008). When such interactions are sustained over time and mutual engagement is consolidated, they may evolve into a boundary practice, which is a hybrid form that combines elements of the communities involved and whose effectiveness depends on trust, critical dialogue, and mutual support (Goos, 2015).

Thus, collaborative work at the boundary becomes a context for mutual engagement where tensions inherent in difference can become opportunities for professional development. The specific ways in which this learning is achieved and translated into new knowledge are further explained through the various mechanisms that emerge during these exchanges.

Potential Mechanisms of Boundary Learning

Learning in boundary contexts can be understood broadly, encompassing the construction of new understandings, the shaping of identities, changes in practices, and institutional development (Akkerman & Bakker, 2011). From this perspective, active participation in social practices that cross boundaries invites individuals to reconfigure who they are and what they do, while simultaneously constructing meaning about their own work (Wenger, 2008). This conception is linked to four dialogical mechanisms that transform encounters between communities into opportunities for learning: identification, coordination, reflection, and transformation (Akkerman & Bakker, 2011).

Identification occurs when the boundaries between communities become visible, uncertain, or overlapping. This mechanism involves two processes: *othering*, in which the explicit recognition of differences allows one practice to be defined in contrast to another; and *legitimation of coexistence*, which refers to the situation of those who participate simultaneously in different communities and must manage the resulting interferences in order to sustain their participation in each and be recognised as legitimate members in both contexts. This mechanism enables the reconstruction of community boundaries and the generation of new understandings, with learning potential tied to the redefinition of identities and affiliations.



Coordination differs from identification in that its purpose is not to reconstruct boundaries, but rather to establish continuity through means that facilitate cooperation. It is primarily associated with the use of boundary objects (Star & Griesemer, 1989; Wenger, 2008) and involves four processes: *communicative connection*, where the use of shared objects makes it possible to articulate exchanges between different practices; *translation*, whereby local meanings are rendered comprehensible to other social worlds in order to balance the ambiguity of boundaries; *permeabilization*, which generates more fluid interactions to the point where differences may cease to be perceived in everyday dynamics; and *routinisation*, through which cooperative procedures become stabilised and integrated into practice.

Reflection is activated when differences between practices are thematised as a resource for learning. This mechanism allows practitioners to recognise something new in both their own and others' practices, and involves two interrelated processes: *perspective making*, which entails making explicit and deepening the understanding of one's own practice; and *perspective taking*, which requires viewing oneself through the eyes of others (Boland & Tenkasi, 1995). Reflection not only contributes to a critical review of current practices but also supports the construction of new professional identities and guides future change in practice.

Transformation constitutes the deepest mechanism, as it entails a radical revision of practices and relationships between communities. This mechanism involves processes such as *confrontation*, when differences are recognised and examined around a shared problem, often through the exploration and discussion of boundary objects; *hybridisation*, which consists of combining elements of different practices to generate something new, whether an artefact, a procedure, or a form of accompaniment; and *crystallisation*, which entails the stable incorporation of these innovations into everyday practice, through new routines, the redistribution of roles, or new modes of regulating collaborative work. In this way, transformation not only transcends the limits of the communities involved but also produces hybrid practices with the potential for renewal.

These mechanisms do not operate in isolation or in a linear sequence. Identification typically focuses on the reconstruction of boundaries, whereas coordination and transformation aim to transcend them. Identification and reflection are mainly associated with meaning-oriented learning (perspectives and identities), while coordination and transformation relate to practice-oriented learning (routines, procedures, and roles). Taken together, the four mechanisms help us to understand how boundary encounters, far from being merely spaces of tension, can become arenas for professional learning and shared development (Akkerman & Bakker, 2011).

Method

This section is structured into three parts. First, it outlines the context of the investigation and the participants. Second, it presents the research design and the data corpus. Third, it details the analytical procedures employed.

Context and Participants

The study took place in the context of a mathematics teacher education programme at a public teacher education institute in Uruguay. In this programme, the practicum constitutes the school-based component of a mathematics methods course: the theoretical component is taught by the MTE at the teacher education institute, while the practical component takes place throughout the school year in a secondary classroom under the guidance of the MT. The theoretical component of the course addresses key didactic and pedagogical issues related to mathematics teaching, such as lesson planning, task design, classroom interaction, and approaches to the teaching and learning of specific mathematical content. During the practicum, the PT attends the MT's classes to observe her practice, participates in instructional activities as directed by the MT, and gradually assumes responsibility for teaching selected lessons. The MTE supervises aspects of the PT's practicum and attends a set of scheduled classroom observations during which both the MTE and the MT jointly observe a lesson taught by the



PT. These occasions constitute the main instances in which the MTE and MT interact directly, and they conclude with a three-way post-lesson conference in which the PT reflects on her teaching and receives feedback from both teacher educators. For reporting purposes the participants were assigned pseudonyms and identity codes to maintain anonymity and confidentiality.

The study participants were Mariana and Mateo, two MTs (MT1 & MT2, respectively), and Marta, Dana, Valeria, and Sergio, four MTEs (MTE1, MTE2, MTE3, & MTE4, respectively). Two PTs, Jesica and Flavia (PT1 & PT2), participated indirectly, as the meetings analysed focused on discussions of their lessons, as described below. Both PTs completed their practicum in public secondary schools: PT1 in a Grade 10 class (students aged 14–15) under the supervision of MT1, and PT2 in a Grade 12 class (students aged 16–17) under the supervision of MT2. MTE1 is the lecturer responsible for the mathematics methods course in the teacher education programme attended by PT1 and PT2 and supervises PT1's practicum together with MT1 and PT2's practicum together with MT2. MTE2, MTE3, and MTE4 are MTE1's colleagues at the teacher education institute and constituted the research team. Although these three MTEs were not part of the MTE1–MT–PT triads, they participated in the organised meetings (see Research design: Encounters 1–5) with the consent of the other participants, as participant-observer researchers (Cooper, 2019). Their inclusion emerged from discussions among the teacher educators aimed at collectively examining practicum experiences. Their participation created an expanded professional space in which multiple perspectives on teaching and supervision were brought into dialogue.

In terms of professional background, the four MTEs brought substantial experience to the study: MTE1 had 25 years of experience teaching the mathematics methods course, while MTE2, MTE3, and MTE4 had 15, 12, and 8 years of experience in teacher education, respectively. This was their first collaboration as a research team, although they had previously worked together as colleagues at the institute. MT1 and MT2 had served as mentor teachers for 3 and 10 years, respectively, and were participating for the first time in a collective discussion space of this kind. Only MTE3 had prior professional contact with one of the MTs, having previously worked with Mateo as part of a supervisory dyad.

Research Design

Methodologically, the study followed a qualitative approach, conceived as an inquiry process oriented towards capturing in depth the meanings of experience (Patton, 2015). It was exploratory in nature, as it sought to investigate a little-studied phenomenon without claims of generalisation (Stebbins, 2001). A single-case study design focused on professional learning was adopted, as it is appropriate for examining specific educational situations in detail and in context (Yin, 2018).

In this case, we analysed discussions between MTEs and MTs that took place in five encounters (see Figure 1). The focus of the discussions was on the feedback provided to PTs after observing their lessons. The first encounter (E1) took place before observations of the PTs' lessons began. During this session, the research objective was presented, and the working procedures were agreed upon: prior to each of the subsequent meetings (E2–E5), each participant was expected to read the lesson plan prepared by the PT and listen to the recording of the feedback session involving MTE1, the PT, and the corresponding MT. Meeting E2 was held after PT1 had taught her lesson, E3 after PT2's lesson, and meetings E4 and E5 took place after both PTs had delivered their respective lessons.



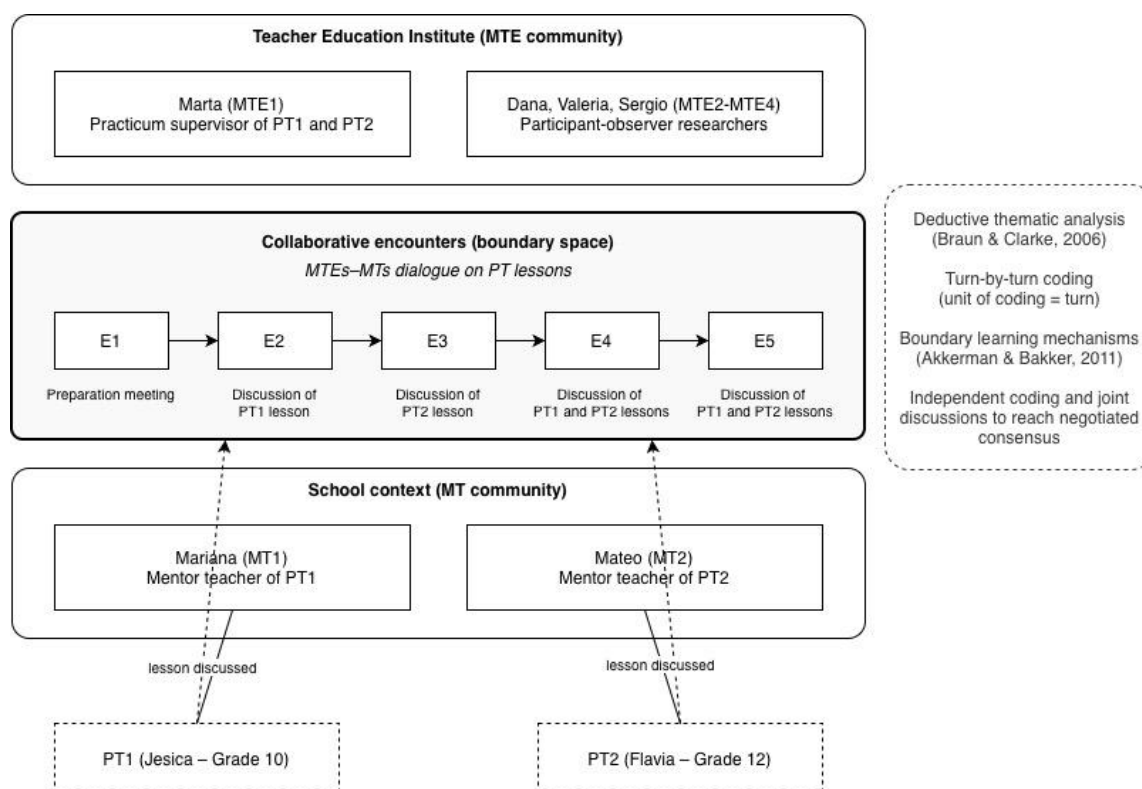


Figure 1. Research design.

The data corpus consists of 717 turns of interaction generated during the five audio-recorded and transcribed meetings (E1: 102 turns, E2: 151, E3: 135, E4: 176, E5: 153). A turn was understood as a contribution produced by a participant before another speaker intervened. These encounters functioned as collective spaces in which the four MTEs and the two MTs contrasted and negotiated their perspectives on teaching and supervision, providing the empirical basis for analysing boundary learning processes.

Analytical Procedure

The study followed a deductive thematic analysis (Braun & Clarke, 2006), guided by the conceptualisation of boundary learning mechanisms (Akkerman & Bakker, 2011), in which the four mechanisms and their associated processes served as predefined analytical categories. The analysis focused on the interactions recorded across the five sessions, which were considered privileged opportunities for examining the nuances of professional boundary learning in this context. To ensure a rigorous identification of these processes in the transcripts, specific empirical indicators and operational criteria were developed for each mechanism and its constitutive. Table 1 presents the operational criteria for each mechanism and process.

Table 1
Coding Scheme

Learning mechanism	Process	Operational criterion
Identification	Othering	Differences between practices or roles are pointed out, making boundaries visible.
Coordination	Legitimation of coexistence	The need to reconcile multiple memberships to sustain participation across communities is explicitly recognised.
	Communicative connection	Shared objects or resources are employed to mediate cooperation.
	Translation	Meanings or criteria are reformulated to be comprehensible to the other community.
	Permeabilisation	Fluid interactions are described in which differences no longer constitute an obstacle.
Reflection	Routinisation	Common procedures are established, repeated, and stabilised over time.
	Perspective making	Assumptions or criteria are made explicit and opened to discussion.
Transformation	Perspective taking	One's own practice is reconsidered from the standpoint of others.
	Confrontation	A shared problem is identified that requires joint discussion.
	Hybridisation	Contributions from different communities are combined in a novel, joint practice.
	Crystallisation	Innovations are consolidated in new routines, roles, or permanent structures.

The analytical procedure involved coding the transcripts turn by turn, with each turn of participation defined as the unit of coding. Each turn was examined to determine whether a boundary learning mechanism and its associated process could be empirically identified according to the predefined analytical categories in the coding scheme (Table 1). For example, a turn was coded as coordination–translation when an MTE reformulated a theoretical pedagogical criterion into classroom-oriented language to make it meaningful within the MT's school context. To enhance trustworthiness, the three researchers engaged in iterative cycles of independent coding followed by joint discussions to compare interpretations and resolve discrepancies through negotiated consensus. This process supported alignment between the theoretical framework and the empirical material.

Results

The analysis of the encounters between MTEs and MTs revealed different manifestations of boundary learning mechanisms (Akkerman & Bakker, 2011): identification, coordination, reflection, and transformation. The presentation of the results is organised around these four mechanisms, illustrating each of them with excerpts from the transcribed meetings that show how they emerge in discussions of the concrete practice of supervising PTs. Interpretation of the learning potential arising from these collaborative encounters is also on offer.

To provide an overview of how these mechanisms were activated across the meetings, Figure 2 presents the distribution of coded turns for each mechanism in each encounter.



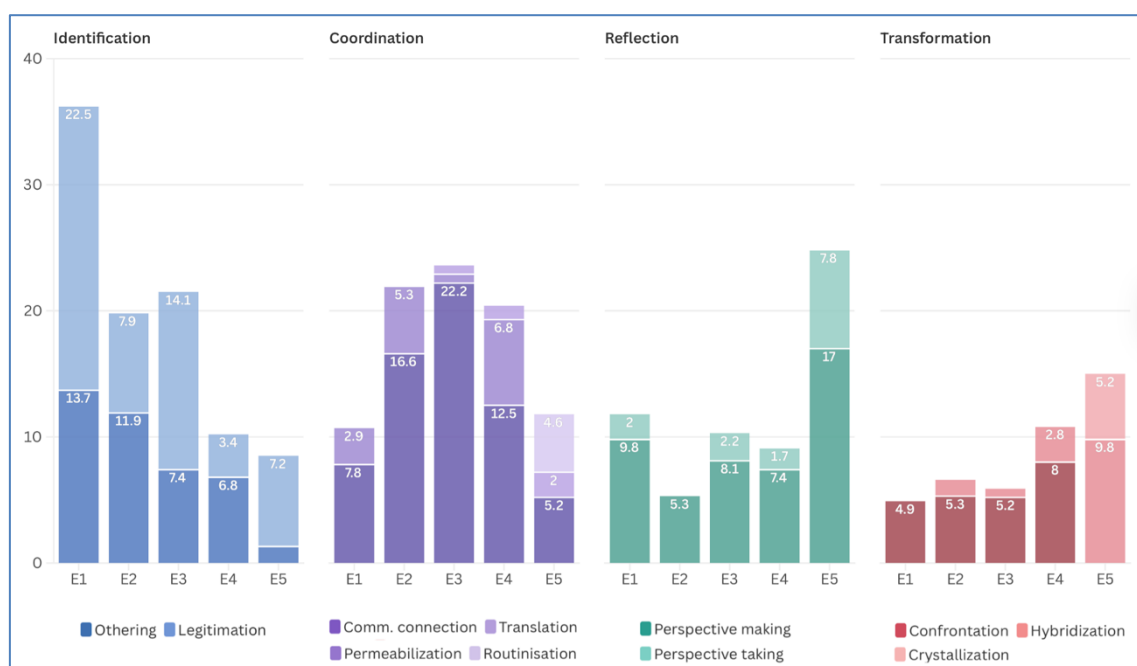


Figure 2. Boundary learning mechanisms and processes across meetings.

Because the analysis was conducted turn by turn, the figure represents the relative salience of each mechanism within the interactional flow of the meetings. Importantly, the figure also reflects the analytical distinction between mechanisms and processes: while the height of each bar indicates the prominence of a mechanism, its internal segmentation shows the specific processes through which that mechanism was enacted in the discussions (e.g., othering and legitimation of coexistence processes for the identification mechanism).

Across the meetings, understood as boundary encounters, different forms of learning were activated with varying intensity. The stronger presence of identification in the earlier meetings suggests that initial collaboration involved making differences in roles, expectations, and evaluative positions visible. As the interactions progressed, coordination and reflection became more prominent, indicating a shift towards sustaining joint work through shared resources and towards examining practice through multiple perspectives. Transformation appeared less frequently, but its presence is analytically significant, as it points to moments in which participants moved beyond negotiating existing boundaries and began to propose or enact hybrid forms of collaboration. At the same time, the segmentation of the bars shows that these mechanisms were not enacted uniformly, but through different processes across meetings, revealing shifts in how boundary learning unfolded in this context.

This overview provides a point of departure for the detailed analysis that follows. The next sections examine each mechanism in turn, drawing on selected excerpts to show how these processes were enacted in discussions about the supervision of PTs.

Identification

In the encounters analysed, the mechanism of identification became evident at different moments when teacher educators made explicit the differences between their practices and positioned themselves in relation to one another. These instances involved processes of othering, through which one practice was defined in contrast to another, and legitimation of coexistence, which required acknowledging that participants engaged simultaneously in different practices must manage the interferences between them in order to be recognised as legitimate members of both communities. Through these processes,

identification enabled the reconstruction of community boundaries and contributed to a redefinition of professional identities.

The following excerpt from E1 illustrates othering:

- MTE1: When I was a mentor teacher, I felt that the teacher educator was also coming to observe and question me. That wasn't really the intention, but that's how it felt to me, because no one had explained how things were supposed to work. I felt observed, evaluated, and that made me try to appear flawless, as if I couldn't make any mistakes—when in fact, we all make mistakes.
- MT1: I feel something similar. You don't really know what the teacher educator is going to evaluate, because each one has their own way of doing things, so the feedback is unpredictable. I also feel evaluated as a mentor teacher because I'm the one who accompanies the student teachers, guides them, and makes suggestions. And if later the teacher educator says, "This isn't right," I immediately think: then I gave them the wrong advice.

In this exchange, MTE1 recalls how, in her early years as a mentor teacher, she perceived the visit of the MTE as an instance of observation and judgment on her own work, which led her to try to present herself without errors. Similarly, MT1 stresses that the absence of shared criteria makes feedback unpredictable and causes her to feel indirectly evaluated, to the point of doubting the advice she had given to the PT. From the perspective of boundary learning, these accounts can be interpreted as a process of othering, since in the practice of accompanying PTs, the differences between communities become explicit: the MTE feedback to PTs is experienced by MTs as a judgement of their own work. Within this framework, the MTE is constructed as another with the power to evaluate and question, while the MT perceives herself as exposed and delegitimised in her role as guide of the PT. The learning potential here lies in the visibility of a discontinuity between MTs and MTEs communities, which redefines the identities involved and highlights the need to reconsider how evaluation and support are articulated in this shared practice.

The following excerpt, also from E1, illustrates the legitimisation of coexistence:

- MT2: When you share a student with a teacher educator, it's essential to meet beforehand and set some criteria. Over time you adjust, and what matters is that the student teacher sees the relationship flowing, that it's a learning process among three people, and that no one is there to attack or defend.
- MTE1: But that's not happening much, and that's the problem.
- MT2: Still, I've noticed a change. Feedback used to be more destructive, but since four or five years ago teacher educators have been more constructive and listen more to the mentor teacher.
- MTE3: It may be that, over time, mentor teachers mature in their role and become more confident in defending their professional position. At the same time, the emergence of research and training focused on the mentor's role has also contributed to this shift. In the past, this work was largely unrecognised; today, it encourages us to view mentor teachers differently and to place greater value on what they do.

In this exchange, MT2 highlights the importance of meeting with the MTE to establish criteria and to show the PT that supervision is a shared learning process rather than a confrontation of roles. At this point, MTE1 acknowledges that such fluency is not always achieved, while MT2 adds that, over time, he has observed more constructive feedback practices by MTE, moving from destructive judgments towards dialogic stances that include MT perspectives. Finally, MTE3 expands the explanation, attributing this transformation both to the accumulated experience of MT and to the institutional recognition generated by research and training on the mentor role. Analysed through the lens of boundary learning, these accounts illustrate a process of legitimation of coexistence, in which the simultaneous participation of MTs and MTEs in different communities becomes compatible: MTs manage to sustain their dual position as classroom teachers and co-educators, while MTEs recognise this contribution as an integral part of PT supervision. The learning potential here lies in the redefinition of professional identities, enabling both actors to coexist and be acknowledged in the shared practice of teacher education.



In summary, the evidence showed that the mechanism of identification enabled participants to recognise discontinuities between communities and to redefine their positions in the supervision of PTs. Through processes of othering, MTs learned to recognise how MTE feedback, although directed at PTs, can be experienced as an evaluation of their own work, revealing the asymmetries in evaluative authority and making visible the boundaries between communities. At the same time, MTEs became aware of how their role is perceived by MTs, particularly the unintended effects of feedback as judgement. Through processes of legitimisation of coexistence, MTs learned to sustain their dual role as classroom teachers and co-educators of PTs, gaining confidence in asserting their professional knowledge, while MTEs learned to recognise and value MTs' contribution as an integral part of PT supervision. Identification thus made boundaries visible and supported learning about how to negotiate and articulate diverse professional identities within collaborative practice.

Coordination

In the encounters analysed, the mechanism of coordination was evident at different moments when teacher educators articulated their interventions and sustained cooperation through shared objects. These instances included the use of lesson plans, assessment criteria, and procedural agreements that functioned as boundary objects, facilitating communication between communities with diverse perspectives. The analysis distinguished processes of communicative connection, translation, permeabilisation, and routinisation, which enabled continuity in the supervision of PTs without requiring homogenisation of MT and MTE practices.

The following excerpt from E2 illustrates communicative connection and translation:

- MTE2: Maybe it would be useful if, when you [MT2] teach circles, she [PT2] observes not only the content but also the kinds of questions you ask and why. That could later help guide her when she plans the topic of parabolas.
- MTE3: Right, so she keeps track of when you focus on conceptual aspects and when you use examples. Then she can draw a parallel with her own class.
- MTE4: Yes, and I'm thinking we could combine two resources. Because Mateo [MT2] said he uses observation sheets with his student teachers, and Valeria [MTE3] mentioned the weekly journal. Maybe if we bring those two things together, we can better guide her on what to pay attention to and what she doesn't need to focus on.
- MT2: I like the idea. I was just thinking of asking Flavia [PT2] to fill out a worksheet while I'm teaching, noting any difficulties she notices among the students.

In this exchange, the MTE highlights the importance of ensuring that the PT observation of the MT lesson is not limited to content but also includes the questions posed and the examples used. A boundary learning reading of these accounts suggests an effort of translation between communities, as criteria drawn from mathematics methods are reformulated to become meaningful in the school context. At the same time, the MTE4 proposal to combine the observation sheets usually employed by MT2 with the logbook promoted by MTE3 illustrates the articulation of boundary objects that integrate different perspectives. Finally, the MT2 appropriation of the suggestion, adapting it to his own practice, reinforces communicative connection by showing how shared resources circulate and are re-signified in the interaction between communities. The learning potential here lies in the joint construction of criteria and tools that provide a broader perspective on teaching, integrating contributions from MTEs and MTs in the supervision of PTs.

The following excerpt from E5 illustrates permeabilisation and routinisation:

- MTE1: In the last meeting we had agreed to work on content, since that was the main difficulty for the student teachers. Did you work on that, Mariana [MT1]?
- MT1: Yes, and we also did something else: she [PT1] wrote down the questions students asked me and the answers. She listened to what they asked, how I responded, and what she would have answered herself.
- MTE1: That really showed in the class. You could see she had started to handle some parts better, because she was able to listen and pay attention to how you responded.



- MT2: She [PT2] always did that: she wrote the questions on one side and the answers on the other. She even told me she found it valuable when I left a silence, because then another student would answer. It was hard for her to process at first, but she still kept track of it.

In this exchange, MT1 refers to the proposal of guiding PT2 through the recording of questions and answers, showing that the suggestion previously discussed between MTE and MT had already been incorporated into classroom practice. From the theoretical perspective, the fact that the MTE recognised the impact of this strategy on PT2's progress, can be interpreted as a process of permeabilisation, in which the boundaries between communities become less visible, and interaction flows more naturally. Within this analytical framework, MT2's description of how PT2 systematically adopted the task of noting questions and answers in every lesson can be understood as reflecting a move towards routinisation, as the procedure stabilises as part of regular supervision. In this way, learning is expressed in practices negotiated at the boundary but enacted in the classroom, which, through repetition and stabilisation, promote the continuity of collaborative work.

In summary, the evidence showed that coordination enabled both MTEs and MTs to learn how to sustain joint work without requiring the homogenisation of their practices. MTEs learned to translate didactical criteria from the methods course into forms that were meaningful within the school context, while MTs learned to appropriate and adapt these criteria and tools within their own classroom practice. Through processes of translation, the linking of observation tools, and the routinisation of procedures that gradually stabilised in practice (e.g., MT1, E5), participants developed ways of coordinating their actions and maintaining agreements over time. In this way, coordination fostered more fluid cooperation, in which community boundaries were softened and continuity in supervision was sustained.

Reflection

In the encounters analysed, the mechanism of reflection appeared in moments when teacher educators highlighted differences between practices and turned them into a resource for reconsidering their own assumptions. These instances were expressed in two processes: perspective making, when participants made their criteria or conceptions explicit so they could be discussed; and perspective taking, when they adopted the viewpoint of others to reconsider their practice and re-signify their formative role.

The following excerpt from E1 illustrates perspective taking:

- MT2: I've worked with teacher educators who look at the lesson plan beforehand and give input, and others who do it in the moment... no one plans or teaches the perfect lesson; each one notices something different. For me, the more debatable it is, the better, because the discussion can remain open, and from there different options emerge.
- MTE4: In my case, the only thing I do is talk with the mentor teacher after the lesson but before the feedback session, so that the student teacher receives a unified message. I thought of it as a way to provide coherence, but listening to you I wonder if maybe I should open up other possibilities. The thing is, I feel uncomfortable interfering with the planning—I feel like I'd be invading the mentor teacher's role.
- MT2: But it's not about guiding them in advance; it's about making sure that, during the feedback, the student teacher can see that there are different perspectives on the same lesson—and that this is also formative.

In this exchange, MT2 argued that no lesson is perfect and that supervision gains meaning when open and plural discussions about PT practices are sustained. In turn, MTE4 described his usual practice of talking with the MT after the PT's lesson but before the feedback session, to transmit a coherent message to the PT. At the same time, he acknowledged that this procedure could be limiting, since it avoided intervention in the prior planning process for fear of invading the MT's role. The MT2 reply, emphasising the formative value of showing the PT different perspectives on the same lesson, led MTE4 to reconsider his assumptions and to open himself to new forms of supervision. When viewed through the boundary learning framework, this dialogue can be interpreted as an instance of perspective taking, as MTE4 re-examines his assumptions by integrating his colleague's viewpoint. The learning potential



lies not only in the reconsideration of individual criteria but also in the opening up of feedback as a shared practice in which diverse perspectives become complementary for PTs.

The following excerpt from the same meeting illustrates perspective making:

- MTE3: How was the experience of sitting on the examination panel for you?
 MTE2: It was an interesting exchange.
 MT2: I always enjoy taking part in these examinations; you learn a lot by seeing how others work. In this case, I liked it even more because I already knew the student teacher's [PT1] background, and that gave me some clues about what to pay attention to.
 MTE3: Right.
 MT2: Given the work we had been doing, I wanted to see if she [PT1] was able to loosen up a bit more, and whether she could conceptualise certain things. Mariana [MT1] had pointed out that she tended to ask herself questions and then answer them, so I wanted to see whether she was now giving more space for students to participate, even if they made mistakes. I know that's difficult, because when you're a student teacher, you tend to think that correct answers help, and incorrect ones hurt. I remember feeling the same way when I was a student teacher.

In this passage, MT2 explained that knowing PT1's previous background allowed him to focus his observation on aspects such as her confidence and the space she gave to student participation. He added that these difficulties were common and related them to his own experience as a PT, when he also privileged correct answers and avoided errors for fear of being penalised. From the perspective of boundary learning, this intervention can be interpreted as an example of perspective making, since MT2 articulated assumptions that usually remained implicit in practice. In making these assumptions explicit and available for collective reflection, he enabled shared learning that supported a more coherent articulation of the roles of teacher educator and PT in supervision.

In summary, the evidence showed that reflection enabled both MTEs and MTs to learn by making their own assumptions explicit and by engaging with the perspectives of others. Through processes of perspective making, participants learned to articulate and render visible the criteria and routines that usually remained implicit in their practice (MT2, E5). Through perspective taking, they learned to reconsider and reframe these assumptions by incorporating alternative viewpoints, which allowed them to re-signify their roles in the supervision of PTs (MTE4, E1). In this way, differences between practices became a resource for learning, supporting the development of more reflective and shared understandings of the formative role in the accompaniment of school practice.

Transformation

In the meetings analysed, transformation was manifested in proposals that sought to generate new forms of joint work between MTs and MTEs. These processes arose from the identification of common problems and led to ideas of hybridisation, such as joint planning, linking theory and practice in PT teaching, or the integration of mixed examination panels. Although not all of these initiatives were fully realised, they demonstrate the potential of sustained dialogue to create hybrid practices that transcend boundaries and reconfigure the modes of supervising school practice.

The following excerpt from E2 illustrates hybridisation:

- MT1: Since we don't have much contact with the teacher educators, we also don't really know what they're covering in the theoretical course. But from our side, we could support that work by showing it in practice: "See this that you're studying in the methods course? Well, here's how you can apply it in the classroom." I think that would be very valuable for the student teacher.
 MTE2: I understand it means more work for the mentor teachers, but we can do it together. What we could start doing is having you propose different tasks as well, so that the student teacher can see a wider variety of lessons.
 MTE3: We could even go ourselves and teach a class with the group, using open-ended tasks or conceptual vignettes, which are hard to design and even harder to implement.



In this excerpt, MT1 points out the limited contact between MTEs and MTs and the resulting lack of knowledge on the part of MTs about what PTs are studying in the mathematics methods course. He then proposes a new practice: making explicit in the practicum the theoretical content addressed in class. This idea is taken up by MTE2, who adds the proposal of joint planning of activities, and by MTE3, who suggests, as a further step, that an MTE could teach a lesson in the school classroom to demonstrate tasks that are theoretically demanding and complex to implement. This dialogue reveals the participants' intention to construct a hybrid practice, combining contributions from both communities for the benefit of PTs. Although it was not fully consolidated, it differs from coordination in that it involves the creation of a new practice that crosses community boundaries.

The following excerpt from E4 also illustrates hybridisation:

- MTE1: To organise the remaining feedback sessions, I suggest that Mariana [MT1] and I continue working with Jesica [PT1], and Mateo [MT2] and I with Flavia [PT2]. But for the final visit, as part of this joint work, the examination panel could include the three of us.
- MT1: I agree that seems best, because that way we would all be supporting both student teachers' processes in some way.
- MT2: Yes, I had never been part of the final examination of a student teacher I had not directly supervised, but in this case, I have been able to follow her process during the year.

In this exchange, MTE1 proposes a new practice: integrating both MTs into the observation and joint evaluation of the final examination of the two PTs. From the perspective of boundary learning, this proposal can be interpreted as an instance of transformation, as it entails the creation of a practice that reconfigures how the two communities engage with one another. This hybrid practice emerged from collaborative work between the two communities and was consolidated as a new way of working together, which was positively valued by all participants, particularly by MT2, as he later emphasised in his reflection in E5.

In summary, transformation enabled both MTEs and MTs to learn how to collaboratively generate new, shared practices that go beyond the mere alignment of existing roles. Through this mechanism, participants learned to reconceptualise the relationship between theory and practice in PT education and to redefine their respective roles in supervision as part of a joint endeavour. This learning was expressed in the design and enactment of hybrid practices—such as the joint articulation of theory and practice in instruction and the integration of mixed examination panels—which reflect an emerging understanding of supervision as a shared and co-constructed responsibility across communities.

Discussion and Conclusions

This study examined collaborative work between MTEs and MTs in Uruguay in the context of supervising PTs, with the aim of exploring how mechanisms of boundary learning are enacted in this work. The analysis showed the presence of the four mechanisms proposed by Akkerman and Bakker (2011)—identification, coordination, reflection, and transformation—but, more importantly, it showed how these mechanisms help to make sense of collaboration in practicum supervision as a specific challenge within mathematics teacher education. Rather than simply confirming the usefulness of the framework, the findings suggest that boundary learning offers a productive way of understanding supervision as a space in which tensions between professional communities can be worked through and re-signified through collaboration, thereby contributing to a more constructive supervisory process.

From this perspective, identification is not only the first mechanism observed in the data, but also a key lens for understanding one of the central tensions documented in the mathematics teacher education literature: the disconnect between university-based and school-based teacher educators (Clarke & Jarvis-Selinger, 2005; Fernandez & Erbilgin, 2009). In this study, that discontinuity became visible when MTs experienced feedback addressed to PTs as also reflecting on their own work, and when MTEs who had previously occupied the MTs role recalled similar experiences of asymmetry and exposure. When read through the framework of boundary learning, these situations show that



collaboration does not begin from shared understandings, but from the recognition of differences in roles, expectations, and forms of authority. This is theoretically relevant because it shifts the interpretation of tension in MTE–MT relations: rather than treating it only as a structural problem or as a lack of the enabling conditions for collaboration identified in prior research—such as trust, mutual respect, and a shared problem (Goos, 2015)—the findings suggest that making differences visible is itself part of the learning process that collaboration may generate. In this sense, identification did not merely expose discontinuities; it made possible a redefinition of roles in which MTs could be recognised as legitimate co-educators (Lafferty, 2018).

The mechanism of coordination, in turn, helps to specify what it means in practice to build coherence across the school–university boundary in teacher education. Prior literature has emphasised the need for more constructive and less fragmented supervision (Butler & Cuenca, 2012), noting a lack of mathematics-specific feedback and differences in supervisors’ connectedness to teacher education programmes (Schwartz et al., 2018), as well as the importance of negotiated or invited forms of participation for MTs (Clarke et al., 2014). The present findings contribute to this discussion by showing that such coherence is not achieved through the elimination of differences, but through the use of shared objects and routines that allow different perspectives to remain distinct while still becoming workable together. In the meetings analysed, lesson plans, observation sheets, logbooks, and routines such as systematically recording classroom questions and answers functioned as mediating devices through which meanings were translated and practices aligned. In line with research on the mediating function of shared objects in encounters between communities with different logics (Goos, 2015; Star & Griesemer, 1989), coordination provided continuity of joint work without requiring homogenisation of practices. The framework of boundary learning thus provides a productive lens for understanding how collaboration is sustained in practice, not through consensus, but through the development of shared ways of working that preserve difference while enabling joint supervision.

The findings related to reflection further strengthen the relevance of the framework for the mathematics teacher education field, because they show that MTEs and MTs are not merely actors who support PTs learning, but professionals who also learn through engaging with one another across institutional and cultural boundaries. In the meetings analysed, reflection emerged when differences in criteria and assumptions were not suppressed but discussed, and when participants adopted the viewpoint of a colleague, thus enabling both perspective making and perspective taking. Theoretical and practical viewpoints were thus not simply contrasted; they became resources for re-signifying formative roles and revising supervision practices. Seen in relation to prior research that has critiqued evaluative feedback and called for more dialogic and reflective forms of supervision (Clarke et al., 2014; Fernandez & Erbilgin, 2009; Schwartz et al., 2018), these findings suggest that collaborative work contributes not only to improving feedback to PTs, but also to fostering mutual learning among teacher educators. Moreover, moving between perspective making and perspective taking broadens interpretive repertoires and supports the construction of new professional identities (Boland & Tenkasi, 1995).

Transformation, finally, is significant not because all the hybrid practices discussed in the meetings became fully established, but because its presence in the data points to the generative potential of collaboration. Joint lesson planning, co-teaching, introducing into school classrooms the types of tasks studied in the theoretical methods course, and mixed panels for PTs final assessment indicate attempts to produce new forms of supervision that combine elements from both communities and emerge from the identification of shared problems. This is theoretically relevant because it shows that, in this context, boundary learning is not limited to improving communication or clarifying roles; it can also support the emergence of new, hybrid forms of practice. At the same time, the findings indicate that transformation is uneven: while some initiatives were enacted and stabilised—such as the joint participation of MTs and MTEs in examination panels—others remained prospective. This nuance suggests that transformation should not be interpreted only in terms of fully consolidated innovation, but also as an ongoing and tentative process that may or may not become embedded in practice.



Taken together, the findings provide a response to the research question guiding this study—namely, how boundary learning mechanisms are enacted in collaborative encounters between MTEs and MTs regarding the supervision of PTs. They show that these mechanisms are enacted as interrelated and overlapping processes that emerge in the discussion of concrete supervisory practices, rather than as analytically distinct phases. The four mechanisms proposed by Akkerman and Bakker (2011) proved useful to characterise the collaborative processes observed: collaboration between MTEs and MTs can be seen not as a linear movement from separation to agreement, but as a process in which discontinuities, mediating objects, perspective shifts, and hybrid practices are all part of professional learning. Nevertheless, the findings also suggest the need to nuance their application in the context of mathematics teacher education. In particular, the mechanism of identification appeared strongly intertwined with issues of evaluative authority, which are especially salient in practicum supervision. This indicates that, in teacher education contexts, boundary work is not only epistemic or cultural but also institutional and evaluative, introducing asymmetries that are less explicitly addressed in the original framework. Thus, rather than operating as analytically distinct phases, the mechanisms seemed to overlap and be shaped by the dual role of supervision as both formative and evaluative.

These findings also extend prior literature on MTE–MT collaboration. As mentioned before, earlier studies have documented conflicting pedagogical approaches, evaluative rather than reflective feedback, and insufficient preparation for the mentoring role (Butler & Cuenca, 2012; Clarke & Jarvis-Selinger, 2005; Fernandez & Erbilgin, 2009; Lafferty, 2018). The present study does not dispute those findings; rather, it reinterprets them by showing that the same tensions may also be understood as conditions under which boundary learning becomes possible. In that sense, the contribution is not to claim that tensions disappear when collaboration is established, but to show that, under conditions of trust, recognition, and dialogue, tensions can be worked with rather than merely managed. This shifts the discussion from whether MTEs and MTs differ to how those differences can become productive within teacher education. In this respect, our findings provide further empirical support for recommendations made in previous studies, including the creation of formal spaces for interaction between school- and university-based teacher educators (Smith, 2000), sustained dialogue across roles and opportunities for mentor development (Goos, 1999), and collaborative practices that connect theory and practice, such as co-teaching (Downton et al., 2018). At the same time, this study extends this literature by showing how, through sustained PT practicum collaboration, differences in roles, knowledge, and perspectives can themselves become resources for developing shared criteria and transforming practices. In particular, the findings illustrate how recurring interactions between MTs and MTEs can move beyond coordination towards joint practices, such as shared lesson planning, co-teaching, and participation in joint assessment panels. These findings also reinforce the importance of institutionally recognising and strengthening the role of MTs and of creating conditions that enable such hybrid practices to be sustained.

In sum, this study contributes to the field of mathematics teacher education by reframing practicum supervision as a boundary space that not only supports prospective teachers but also enables the professional learning of teacher educators. By showing how boundary learning mechanisms are enacted, intertwined, and shaped by evaluative and institutional conditions, the study extends the applicability of the boundary learning framework to teacher education contexts. It also highlights the importance of designing collaborative structures that make such learning visible and sustainable, thereby contributing to ongoing efforts to strengthen coherence across sites of teacher education. Future research could explore other institutional and disciplinary contexts to compare the functioning of boundary learning mechanisms, as well as analyse the sustainability of emerging hybrid practices over time, examining whether they can become institutionally embedded. It is also important to investigate the impact of these dynamics not only on MTEs and MTs, but also on the learning and professional identity of PTs.



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Competing interests

The authors declare there are no competing interests.

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