# **Implementation in context:** Tensions between expectations and goals in a preschool mathematics implementation project

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**Abstract:** This paper examines preschool teachers' experiences of participating in a preschool mathematics implementation study, as well as how the role of facilitators was perceived during the implementation process. The study draws on data from 21 focus group interviews and a digital survey. The results show that many preschool teachers interpreted the implementation through the lens of professional development, emphasizing collaboration, reflection, leadership engagement, and institutional support. This interpretation created tensions between teachers' expectations of guidance and feedback and the implementation design's intended emphasis on teacher autonomy. The findings further demonstrate that implementation quality is not only a matter of what is implemented, but also about how it is taken up, by whom, and under what conditions. A well-functioning local organization, including leadership support and opportunities for collaboration, emerged as a critical factor for meaningful and sustainable implementation.

**Keywords:** implementation, professional development, early mathematics, preschool

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## 1 Introduction

Research on educational implementation examines how plans, curricula, or programs are enacted in practice and whether they result in lasting changes (Century & Cassata, 2016; Fullan, 2007). This research highlights the importance of examining how teachers engage with and interpret implementation processes, as these factors influence how innovations are enacted in practice (Century & Cassata, 2016). Teachers' experiences during implementation are important, as they influence attitudes toward the innovation being implemented, and positive attitudes are strongly linked to successful and sustained change (Clayback et al., 2023; Fullan, 2007). This study is situated within the context of Swedish preschool mathematics education, where teaching emphasizes both play-based learning and opportunities for mathematical learning, as outlined in the national curriculum (Swedish National Agency for Education, 2025). Research in early mathematics education emphasizes

that teaching requires teachers to connect their understanding of mathematical content with pedagogical strategies that are appropriate for young children, supporting meaningful learning experiences and long-term mathematical learning and understanding (Björklund & Palmér, 2024; Bittner & Bull, 2022; Opperman et al., 2016). Against this background, this paper reports on an implementation study focusing on preschool teachers' experiences of participating in the implementation study, as well as their perceptions of the facilitators throughout this process.

The interest in investigating preschool teachers' experiences arose from observing that some teachers described the implementation in terms typically associated with professional development. This suggests that their experiences may have been shaped by professional learning processes. Given that implementation and professional development have several commonalities, this is not surprising: both involve teachers, aim to bring about change, and emphasize the importance of relationships between facilitators, teachers, context, and outcomes (Avalos, 2011; Century & Cassata, 2016). However, there are also important differences, particularly regarding the role of the facilitators. In professional development, facilitators typically work closely with teachers in collaborative processes (Avalos, 2011). In contrast, implementation research often emphasizes a facilitator role characterized by a certain degree of distance, intended to support teachers' independent enactment of innovations (Century & Cassata, 2016). This is partly due to the involvement of larger communities, which implies a higher number of participating teachers, and partly to ensure that the innovation can be implemented independently of a facilitator (Century & Cassata, 2016).

Drawing on the similarities and differences between implementation and professional development discussed above, the study is guided by the following research questions:

RQ1: How do preschool teachers perceive the role and support of facilitators during implementation?
RQ2: How can preschool teachers' expressed experiences of participating in an implementation study be understood in relation to implementation quality?

In this study, implementation quality refers to the extent to which the implementation process was coherent, consistent, and aligned with its intended goals, including how well it supported teacher engagement and long-term change (Century & Cassata, 2016). By examining preschool teachers' experiences, the study

contributes to understanding how implementation unfolds in early childhood mathematics education and provides valuable insights into how implementation can lead to successful and sustained change in early childhood education.

## 2 Implementation and professional development in education

In educational settings, implementation research conceptualizes the process through which educational innovations—such as curricula or programs—are adopted, enacted, and sustained. This includes not only implementing the innovation in practice, but also maintaining fidelity to its core components, allowing adaptation to local context, and studying how teachers interpret and integrate the innovation into their teaching practice (Fullan, 2007; Coburn, 2003; Century & Cassata, 2016; Thomas et al., 2018). Implementation is therefore not only about providing or delivering a curriculum or program, but also about understanding the processes through which it becomes embedded in teachers' daily practice. It refers to the process of putting plans, curricula, or programs into practice and the extent to which these efforts result in intended learning outcomes (Fullan, 2007; Thomas et al., 2018).

Within implementation research, the notion of scale is crucial. Coburn (2003) argues that traditional definitions of scale have often been limited in scope, focusing primarily on expanding the number of schools or teachers involved, rather than focusing on the quality and depth of change. To address this, Coburn (2003) proposes an alternative definition of scale that includes attention to the nature of change in instruction, sustainability over time, the spread of norms, principles, and beliefs, and shifts in ownership that allow innovations to become self-generative. In early childhood mathematics education, achieving this requires adapting activities to play-based learning and taking teachers' pedagogical and mathematical values and beliefs into account. Similarly, Century and Cassata (2016) highlight that implementation efforts that isolate, decontextualize, or oversimplify complex issues risk reducing the relevance and applicability of educational innovations.

While research on implementation focuses on how innovations are enacted and sustained, research on professional development provides insight into how teachers acquire, interpret, and apply knowledge in practice. Professional development refers to the ongoing process through which teachers enhance their skills, knowledge, and competencies related to their profession. This can include formal training, workshops, conferences, mentoring and self-directed learning (Avalos, 2011).

Cochran-Smith and Lytle (1999) identify three conceptions of teacher professional development: knowledge for practice, knowledge in practice, and knowledge of practice. Knowledge for practice refers to the acquisition of knowledge already established by others; knowledge in practice views teaching as a craft learned through the act of teaching; and knowledge of practice involves teachers using their own classrooms to investigate student learning, knowledge, and theories of learning.

Both implementation research and research on professional development recognize that educational initiatives can be studied at multiple levels. Implementation is typically studied at the individual, organizational, and system levels, reflecting how innovations are adopted and sustained among teachers, schools, and in broader educational systems (Century & Cassata, 2016; Avalos, 2011). Professional development is often examined at micro, meso and macro levels, highlighting how teacher learning and engagement can be organized within schools, across schools, or at the district or national level (Avalos, 2011; Sowder, 2007). Both frameworks emphasize that initiatives can be tailored and studied at different scales of practice, providing insight into how educational change occurs at multiple levels. However, regardless of level, the direction of change is determined by the innovation being introduced (Century & Cassata, 2016). Within implementation research, not all components of an innovation are equally important: some are considered core components, serving as key mechanisms for change (Century & Cassata, 2016). Successful implementation therefore requires identifying which components are essential, along with determining for how long and with what intensity they should be implemented and deciding which components may be adapted or modified to fit local contexts (Coburn, 2003).

Across both implementation research and research on professional development, teachers' experiences, attitudes, values, and beliefs are identified as central to change processes, as they directly influence how innovations and professional learning opportunities are interpreted, enacted and sustained (Clayback et al., 2023; Fullan, 2007; Philipp, 2007). Positive attitudes and beliefs tend to foster engagement and commitment, whereas negative attitudes and beliefs may lead to resistance or superficial compliance (Fullan, 2007). Professional development research further shows that teachers' beliefs about the nature of mathematics, whether it is seen as procedural or conceptual, meaning-making activity, influence how teachers interpret and apply professional development (Cross, 2009). Professional development that actively challenges existing beliefs while remaining

closely connected to teaching practice is more likely to result in meaningful and lasting change (Beswick, 2012).

In early childhood mathematics education, these issues are particularly salient due to the emphasis on play-based education and child-centered approaches, which influences how early childhood mathematics content and teaching practices are understood, interpreted and developed in daily practice. Aligning teachers' mathematical and pedagogical values and beliefs is therefore essential for successful implementation (Perry & Dockett, 2008; Clements & Sarama, 2009; Clayback et al., 2023). Research indicates that collaborative learning opportunities, discussions focused on mathematics, the use of tools, and structured reflection on teaching experiences—particularly when sustained over time—can support changes in classroom practice (Avalos, 2011; Desimone, 2009; Lefstein et al., 2020; Sowder, 2007). These characteristics are also associated with implementation processes that are more likely to result in meaningful and lasting change.

While research on professional development provides insights into how teachers learn and engage with new practices, this study specifically focuses on how preschool teachers experience the implementation of an innovation focused on mathematics. By examining teachers' experiences during the process, the study explores how these influence the enactment and sustainability of the intervention, including factors such as meaning-making, ownership, perceptions of facilitator involvement, and local organizational conditions. Understanding these experiences highlights how teachers' beliefs, pedagogical practices, and reflections interact with the intended goals of implementation, offering insights relevant to both implementation and professional development research.

## 3 Framework

Coburn's (2003) conceptualization of scale encompasses four interrelated dimensions: depth, sustainability, spread, and shift in ownership which together capture not only the breadth but also the quality with which an innovation is enacted and embedded in practice.

Depth refers to the nature and quality of change in teachers' beliefs, norms, and classroom practices beyond superficial use of materials or procedures. Sustainability concerns whether these changes are maintained over time. Spread involves not only the extension of implemented ideas to more contexts but also the dissemination of associated norms, principles, and pedagogical beliefs. Ownership occurs when

teachers and other practitioners internalize and take responsibility over the innovation, adapting it to their local context and sustaining it without reliance on external support, reflecting a shift in reform ownership from external actors to local practitioners.

Previous research has used Coburn's (2003) dimensions of scale to clarify how implementations are conceptualized in mathematics education research, highlighting how depth, sustainability, spread, and ownership can bring conceptual precision to discussions of scaling and implementation beyond mere reach (Sánchez Aguilar et al., 2023). This illustrates the utility of the framework for understanding implementation quality to understand implementation in terms of meaningful and lasting change, beyond simple counts of schools or teachers. This study draws on Coburn's (2003) framework to examine implementation quality in Swedish preschool mathematics education, using the four dimensions to investigate teachers experiences of participating in the implementation and how they perceive the role and support of facilitators during implementation. According to Coburn (2003) and Cobb and Jackson (2015), meaningful implementation requires attention to all four dimensions to achieve enduring change, and these dimensions interact to shape how teachers engage with and sustain educational innovations.

## 4 The innovation

This paper reports on an implementation study situated in the context of Swedish preschool mathematics education. In Sweden, preschool is offered to children from the age of one until they begin compulsory school at the age of six. Preschool teachers hold a university degree in early childhood education and typically work alongside preschool assistants, who may have vocational training in early childhood education and care.

According to the Swedish preschool curriculum (Swedish National Agency for Education, 2025), play-based and age-appropriate teaching is to be conducted in different subject areas, including mathematics. In a prior intervention study, such age-appropriate teaching was designed to give the youngest preschoolers the best conditions for learning mathematics. This approach was developed and tried out in authentic preschool settings (see for example Björklund & Palmér, 2022; Palmér & Björklund, 2023; financed by the Swedish Institute for Educational Research, grant no. 2018-00014). The designed teaching was shown to be successful, demonstrating both quantitative and qualitative improvements in how children in the intervention

group used and engaged with numbers. Based on these positive results, the implementation study focused on in this article was initiated (financed by the Swedish Institute for Educational Research, grant no. 2022-00010).

## 5 The implementation

The implementation study was conducted in line with educational design research (Bakker, 2018), which implies implementation in iterative cycles in which new preschools were successively included. As a first step, the core components of the innovation were identified (Century & Cassata, 2016). Based on these components, a text-based guiding material for teachers was developed to support the implementation. The guiding material was structured around the identified core components; that is, the "unique" and the "necessary but not unique" aspects of the intervention (Century & Cassata, 2016, p. 182). The guiding material consisted of five parts, each corresponding to one core component; (1): mathematizing; (2): contrast and generalization; (3): representations; (4): cardinality; and (5): part-whole relations of numbers. Each part included a short text to read, a video illustrating the content in authentic teaching situations, questions for collegial discussion, one activity to be carried out with children, and one activity to be planned and carried out by the teacher.

Preschool teachers implemented the guiding materials with minimal contact with the researchers. Throughout the implementation, the research team maintained a low level of involvement, limited to practical communication via email. In addition, the researchers collected data to investigate the outcome of the implementation, including both interviews and a survey designed to capture teachers' experiences and perceptions of the implementation. The researchers acted as facilitators in an intentionally limited sense: they provided the guiding material, conducted the interviews, and administered the survey. Beyond these tasks, the facilitators did not engage in any additional pedagogical or instructional interactions with the participants.

## 6 Method

As mentioned above, this implementation study was conducted in line with educational design research (Bakker, 2018), involving iterative cycles in which new preschools were successively included. The focus of this article is on a design cycle

where all seven preschools from a single municipality participated, comprising a total of 18 preschool units. The implementation of the innovation was studied at both the individual and organizational level (Century & Cassata, 2016). The municipality was selected for participation in the implementation study based on the principal's expressed interest in the project.

The data for this article consists of focus group interviews with preschool teachers and a digital survey distributed to all participating teachers. The focus group interviews were conducted digitally across five occasions, with one set of interviews after the implementation of each part (core component) of the innovation. To ensure that all preschool units were represented while keeping group sizes manageable, multiple focus groups interviews were held at each interview occasion, with 4-6 teachers in each group. Participants from each unit were included based on practical considerations at each preschool to minimize disruption to daily activities, resulting in different teachers attending different occasions. Some teachers participated in multiple interviews, while others attended only one. In total, 21 focus group interviews were conducted, each lasting approximately 45–60 minutes. The aim of the interviews was to evaluate the function of the guiding material, that is, how it was used, interpreted, and experienced, rather than to supervise or instruct the teachers. A set of guiding questions was used during the focus groups interviews, for example:

- Give an example of something in the guiding material (e.g., text, activity, film) that you/your team experienced as clear. What made this clear?
- If you were to explain what you just identified as clear to a colleague who is not involved, what would you say?
- Was there anything in the message of the text that you perceive as different from how you usually talk about and/or teach mathematics in preschool?
- Did you make any adaptations to the described activities? If so, which ones and why?

The digital survey was administered via email after the implementation of all five parts of the innovation. It included 18 questions, combining multiple-choice items with open-ended questions. The questions addressed teaching practice, perceived changes, challenges, and professional learning during the implementation of the innovation. The teachers were encouraged to reflect on their involvement, as their perspectives were considered essential for understanding the outcomes of the

implementation study. One reminder email was sent during the response period to encourage participation, and in total, 22 of the 55 (40%) preschool teachers completed the survey.

Participation in the study was voluntary, and informed consent was given by the preschool teachers. All responses were anonymized.

### 6.1 Analysis

The analysis drew on both data sources: the survey responses and the focus group interviews. Survey data included both quantitative indicators (e.g., frequency of use, perceived challenges) and open-ended responses that captured individual reflections. A content-focused, iterative analysis inspired by thematic analyses (Braun & Clark, 2006) was conducted. The open-ended responses were read several times, and patterns and themes in the data were identified, focusing on teachers' experiences of the innovation and the role of the facilitators. Coding was conducted collaboratively, with discussions among the research team to ensure consistency and reliability.

Next, the focus group interview data were used to contextualize and enrich the survey findings, providing insights into how teachers interpreted, enacted, and adapted the innovation in practice. Insights from the interviews were integrated with the analyzed responses from the survey. As a final step in the analysis, to investigate how the expressed experiences of the teachers could be understood in relation to implementation quality, the expressed experiences of participating in the implementation study were connected to Coburn's (2003) four interrelated dimensions of quality in implementation: depth, spread, ownership, and sustainability to explore how the implemented innovation supported meaningful and lasting changes in early mathematics teaching in preschool.

## 7 Results

The results are presented in relation to the two research questions. First, the focus is on how the preschool teachers perceive the role and support of facilitators during the implementation. Thereafter, the focus shifts to how preschool teachers' experiences of participating in an implementation study can be understood in relation to implementation quality, including depth, spread, ownership, and sustainability.

### 7.1 Experiences regarding the role and support of the facilitators

The findings indicated that the role of the facilitators, as well as participation in the focus-group interviews, was experienced differently among the preschool teachers, reflecting variations in expectations regarding feedback, supervision and professional dialogue during the implementation of the innovation. While some teachers described the interviews as being inspiring and affirming, others noted limited feedback and supervision from the facilitators, limited interaction, uneven participation, or a negative tone in discussions from other participants.

The preschool teachers expressed that the guiding material provided structure, guidance, and support for reflection. At the same time, they quite often expressed uncertainty, particularly regarding whether they had correctly understood the content in the guiding material and whether their teaching aligned with the intentions of the innovation. Teachers articulated this uncertainty as a concern about “thinking the wrong way”.

> Let me know if I’m thinking wrong, because I’m afraid, I’m thinking wrong all the time.

Some teachers described a sense of having “lost their way”, unsure if they had interpreted the guiding material correctly. In these cases, they expressed a lack of input from the facilitators during the focus groups interviews, particularly concerning whether their teaching practices and interpretations of the guiding material were appropriate.

> We feel a bit lost in this right now.

> We thought we did it right in the beginning, but then my colleague who participated in the previous interview… she was like, 'we didn’t exactly do it wrong… but we misunderstood.' So now we feel like we have lost track of what we are supposed to do.

This uncertainty was often connected to a perceived lack of opportunities to discuss reflections with knowledgeable others.

> Even if you talk to your colleague, you still feel a bit alone. You have thoughts and reflections, and you want to bounce them off someone.

These expressions highlight a perceived need for additional support, which, however, was not the intended purpose of the interviews and is not typically part of implementation research. Some teachers also expressed uncertainty about follow-up and long-term engagement with the innovation.

> How will this be followed up? Will we get any feedback on this in a year or so? If nothing gets sent to us, I think we will have forgotten all about this in a year.

Taken together, these findings point to a discrepancy between some participants' expectations of the interviews (i.e., as opportunities to receive support for their professional development) and the intended purpose of the interviews, which was to study the implementation process. Although the facilitators were not expected to provide guidance or professional development, the participants' comments suggest that such support was anticipated. This gap between expectations and the actual role of the facilitators may have influenced how both the interviews and the role of the facilitators were experienced.

At the same time, these experiences were not shared by all participants. Not all teachers described the focus group interviews as a source of uncertainty or as requiring extensive facilitator input. Some participants expressed confidence in their interpretations of the guiding material and described the interviews primarily as opportunities for exchange and confirmation rather than guidance. In these cases, teachers emphasized collegial learning and recognition rather than external validation.

> It has been interesting to listen to the other participants and how they carried out the tasks. When you hear how others have worked, that is very good – other people's experiences and ideas.

For these teachers, hearing that others had approached the activities in the guiding material in similar ways contributed to a sense of reassurance and professional confidence rather than insecurity.

> It is important to hear others' perspectives, and to hear that you have "thought along similar lines" and are on the right track.

Taken together, these findings indicate that preschool teachers perceive the role of facilitators in different ways, highlighting variations in expectations concerning support, feedback, and professional dialogue. These differing experiences with facilitators provide context for how teachers engaged with the innovation and how it developed in terms of depth, spread, ownership, and sustainability.

## 7.2 Experiences of implementation in connection to depth, spread, ownership, and sustainability

Guided by Coburn's (2003) framework for understanding educational change, this section presents findings related to implementation quality, focusing on ownership and engagement, depth and adaptation, and conditions for spread and sustainability.

### 7.2.1 Ownership and engagement (from external mandate to professional meaning)

In terms of ownership, the findings show that teachers initially experienced the implementation as externally mandated, with ownership developing gradually through engagement and meaning-making. The implementation was initiated through leadership decisions at the municipal level. As a result, many teachers reported entering the project without active involvement in the initial decision, and in some cases, without a clear understanding of why their preschool was participating. This led to a relatively low level of initial ownership, with participation often experienced as externally mandated.

Although this initial framing positioned teachers more as recipients than active collaborators, ownership emerged to be a dynamic rather than a fixed condition. Several participants described how their engagement increased over time, particularly as they began to see connections between the content of the innovation and their own pedagogical values, beliefs and goals.

> Much of it we already did before, but now we have been reminded and have words for it.

Others described the project as contributing to a shared professional language that supported collective ownership.

> We use the concepts we have learned and talk more with each other about mathematics and learning.

This process of meaning-making (connecting the innovation to their own teaching practice) was crucial for building and strengthening their ownership and engagement, turning a mandated project into a meaningful learning process supporting educational change.

For some teachers, the project aligned with ongoing efforts to strengthen mathematics in the preschool practice, while others viewed it as an opportunity for (collegial) professional development or as a chance to try something new. A minority expressed a more skeptical or indifferent stance, pointing to unclear goals or limited influence over the project. Nevertheless, ownership and engagement generally increased when teachers could relate the innovation to their own teaching experiences.

In preschools where principals, according to the preschool teachers, prioritized the project, allocated time for planning and reflection, and engaged in follow-up activities, teachers reported feeling more motivated and supported. In contrast, where leadership provided limited or no support, implementation efforts often remained fragmented, and teachers struggled to see the relevance of their involvement in the study. This highlights how ownership is co-constructed: it depends not only on the teachers' motivation but also on organizational conditions that allow for meaningful participation and agency.

### 7.2.2 Depth and adaptation

The findings indicate that the implementation supported changes in teachers' awareness of mathematical content and professional language, particularly when opportunities for reflection and adaptation were present. Many preschool teachers described the implementation as a learning process, noting that they became more conscious of the mathematics embedded in everyday practice and more deliberate in how they communicated mathematical concepts to young children, focusing on one concept at a time, using consistent language, and reflecting on how mathematical ideas were introduced.  A recurring theme was the development of a shared professional language, including terms such as cardinality, mapping, representation, and contrast, which became tools for planning and reflection. For some teachers, this helped articulate and sharpen practices that had previously been intuitive or implicit.

> I am more clear in my teaching when I present an activity to the children.
>
> Seeing mathematics more clearly in everyday situations – putting on ”mathematics glasses”.

Depth was strongly associated with opportunities for collaboration and reflection. Preschools that provided time and structures for joint planning and post-activity evaluation fostered professional dialogue and shared learning. However, such opportunities were not always present. Several teachers reported working individually, facing time constraints, or lacking systematic support to engage with the guiding material in depth. In some cases, planning had to be done outside working hours, and documentation requirements (such as filming), posed logistical challenges.

Adaptation of activities to local contexts emerged as another central feature of the implementation of the innovation. Depth was evident when teachers described integrating activities and core components from the innovation with existing practices and tailored activities to the need of specific children, considering for example age, group size and interest. Teachers described that they appreciated the structured and concrete nature of the activities in the guiding material, particularly the use of representations. At the same time, the possibility to adapt the activities in the guiding material was described as crucial for successful implementation. Small-group work was frequently used to facilitate engagement and differentiation, especially for the youngest children. Some activities were perceived as either too abstract or too simplistic, requiring reinterpretation or replacement. Despite these challenges, teachers described moments of learning, especially when they were able to connect the content of the guiding material to spontaneous play or exploration of the environment. These findings suggest that depth is not simply a function of exposure to an innovation, but depends on teachers' opportunities to reflect, adapt, and integrate new ideas into their ongoing teaching practice.

### 7.2.3 Spread and sustainability

In relation to spread and sustainability, the findings suggest that collaborative structures and leadership engagement were crucial for maintaining and extending the innovation over time. The potential for the innovation to spread within and across preschools was closely tied to collaborative structures and leadership engagement. In several cases, teachers described working collaboratively, sharing plans, and engaging in joint reflection. This collaboration facilitated a shared understanding and supported continuity in practice. Conversely, when implementation was carried out by individuals or lacked coordination between colleagues, the innovation risked becoming fragmented.

Sustainability appeared contingent on both material integration and institutional support. Teachers who had embedded the content of the innovation, such as consistent use of mathematical language and representations into daily routines or play, expressed a desire to continue this work beyond the formal project. However, concerns were raised about the lack of long-term structures to support continuation, particularly in the absence of leadership follow-up or ongoing time for reflection. Sustainability was expressed as vulnerable in contexts where time, continuity, or leadership engagement was lacking. Several participants expressed uncertainty about whether the project would have any lasting impact without continued support.

Overall, the findings indicate that the potential for spread and sustainability was uneven and context dependent. While some preschools had begun to integrate the innovation into everyday routines, others described the work as closely tied to the formal project structure. This highlights the vulnerability of sustainability when implementation relies primarily on individual commitment rather than embedded institutional structures.

## 8 Discussion

This study examined preschool teachers' experiences of participating in an implementation study focusing on mathematics, including their perceptions of facilitators. The findings show that implementation is not merely the delivery of guiding materials, but a complex process shaped by teachers' interpretations, expectations, and the organizational conditions under which it takes place. A key insight is the discrepancy between teachers' expectations of facilitator input and the study's design, highlighting a tension between implementation and professional development approaches. These findings suggest that implementation is not only a question of what is implemented, but also how it is taken up, by whom, and under what conditions.

Several teachers expressed a desire for feedback, confirmation, and input regarding whether their interpretations of the guiding material and teaching practices were "correct," expectations typical of professional development contexts, where facilitators typically engage closely with teachers in guided learning processes (Avalos, 2011). In contrast, implementation research often positions facilitators at a greater distance to observe how innovations are independently interpreted, adapted and implemented (Century & Cassata, 2016), creating a tension that shaped teachers' experiences of participation in the implementation study. Some teachers'

felt uncertain or “lost”, while others found opportunities for reflection and professional learning within this structure. The findings reflect the distinction between knowledge for practice, where teachers acquire established knowledge, and knowledge of practice, where teachers use their own teaching to investigate children’s learning, knowledge and theories of learning (Cochran-Smith & Lytle, 1999). In this study, the implementation provided opportunities for teachers to engage in knowledge of practice by interpreting, adapting and reflecting on the guiding material and their own mathematics teaching.

Despite that the teachers expressed lack of input from the facilitators, they described their participation in the implementation study as a learning process which increased their awareness of mathematical concepts, strengthened their professional language, and supported reflection on their mathematics teaching practices. The guiding material helped make previously intuitive practices explicit, supporting shifts in instructional routines and deliberate teaching choices. Importantly, this professional growth occurred even without traditional professional development structures, demonstrating that meaningful learning can be embedded within implementation. Depth, however, was uneven across preschools: teachers with collaborative opportunities and supportive organizational conditions reported more substantial changes, emphasizing that engagement depends not only on content quality but also on organizational structures and opportunities for collegial reflection. Where time was scarce or coordination was lacking, engagement remained more superficial.

Ownership initially emerged as limited because participation in the implementation study was mandated by municipal and preschool leadership, positioning teachers more as recipients than active participants. However, over time, teachers’ sense of ownership increased as teachers connected the innovation to their pedagogical values and beliefs, made interpretive decisions, and collaborated with colleagues. Teachers reported that learning new concepts and terminology helped them recognize and articulate the mathematics already embedded in everyday preschool activities. Leadership support, including prioritization, time allocation, and follow-up, was critical in fostering ownership, whereas limited involvement contributed to fragmented enactment. These findings illustrate that ownership develops dynamically through interpretation, negotiation, and meaning-making across different levels (Avalos, 2011; Century & Cassata, 2016; Sowder, 2007) highlighting the interplay between leadership, collaboration, and teacher agency.

Collaboration emerged as central for spreading the innovation and supporting sustainability. Although collaboration was encouraged in the guiding material, meaningful collaboration required support at multiple levels. At the macro level, municipalities needed to provide time, continuity, and structures for collaboration; at the meso level, preschool leadership needed to organize opportunities for joint planning and reflection; and at the micro level, teachers needed opportunities to engage in shared meaning-making and discussion of the innovation. Where collaboration or leadership support was lacking, implementation risked becoming fragmented and fragile. Sustainability depended on making the innovation part of everyday routines, having organizational support, and providing time for teachers to reflect together. Teachers also expressed concern that without continued support and follow-up, innovations might fade out. These findings emphasize that high-quality implementation relies on collaboration and organizational support at all levels.

Drawing on these findings, a broader reflection emerges on what it means to implement an innovation. Implementing innovations is more than delivering guiding materials; it is a process shaped by teachers' interpretations, pedagogical values and beliefs, and the conditions of enactment. The study highlights tensions between autonomy and fidelity, structured guidance and flexible adaptation, and implementation and professional development. Navigating these tensions through clear facilitator roles, collaboration, and leadership support can foster collaboration, reflection, local adaptation, and professional learning. High-quality implementation depends on engagement across multiple levels, with leadership and organizational structures enabling ownership, collaborative reflection, and sustainable practice.

Practical implications include providing clear guidance on facilitator roles, creating structured opportunities for teacher reflection and collaboration, and embedding innovations into daily routines. Leadership support, time allocation, and institutional structures are also critical for ensuring that innovations are meaningfully integrated and sustained.

These results raise important questions for future research and practice: How can leadership support implementation in ways that promote teacher ownership? Which strategies can strengthen deeper engagement and ownership among teachers in implementing research-based innovations? What structures or support are needed to ensure innovations continue beyond the implementation period?

Addressing these questions may help bridge the gap between implementation and practice, contributing to sustainable, locally grounded change in early childhood (mathematics) education. Future research should also examine how facilitator roles and organizational conditions can strengthen teacher engagement, ownership, and long-term sustainability of educational innovations.

### 8. 1 Methodological considerations and limitations

This study is based on preschool teachers' self-reported experiences of participating in an implementation study. Consequently, the findings reflect teachers' perceptions and experiences of engagement, professional learning, uncertainty, and adaptation during the implementation process, rather than independently observed changes in enacted teaching practices. While such data are well suited for exploring processes of meaning-making, ownership, and perceived implementation quality, they do not allow for direct conclusions about the extent or long-term durability of changes in practice or effects on children's learning.

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