

Kindergarten Teachers' Experiences in a Spatial Orientation Skills Professional Development Program

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Abstract

Although earlier studies have documented the importance of spatial orientation skills in early childhood development, teachers often need more experience and guidance in teaching these skills. This research investigates how two kindergarten teachers, guided by two teacher education researchers, utilized Learning Trajectories (LT) in a Professional Development (PD) program to enhance their instructional practices in teaching spatial orientation skills. Employing a qualitative research approach, researchers collected data through semi-structured interviews, field notes, and documents prepared by the teachers and analyzed it using content analysis. Findings reveal that the program provided teachers with a framework for making instructional decisions and facilitated children's engagement in spatial orientation tasks. However, there is a need for further in-service programs on child assessment using LT and instructional activities to improve target skills. This study highlights the potential of LT-based PD programs in fostering effective teaching of spatial orientation skills while identifying areas for further improvement in teacher education.

Keywords

early childhood, learning trajectories, professional development, spatial orientation, teacher education

Introduction

Spatial orientation refers to understanding the positions of objects in space, their relationships with each other, and the symbolic representations of these relationships (e.g., maps) (Clements & Sarama, 2021; Moss et al., 2016). It includes knowing our position and how to move our body in space to achieve specific goals and making similar decisions in the future in more abstract contexts, such as when using maps and coordinates (Uttal & Sheehan, 2014). Knowledge of space and its representations enhances problem-solving and decision-making skills (National Research Council, 2006). Increased awareness of space also helps children make cognitive, emotional, and social connections with their physical environment and reinforces their sense of belonging (Brillante & Mankiw, 2015). Furthermore, studies show a high correlation between success in spatial orientation skills and solving geometry problems (Karaman & Toğrol, 2009; Tartre, 1990). Literature also suggests a strong connection between spatial and numerical skills at an early age (Gunderson et al., 2012; LeFevre et al.,

2013). Understanding the relations among objects in space seems to contribute to math skills, particularly in comprehending the placement of numbers on a number line and their interrelationships. Number line estimation tasks are favorable among researchers to explore the relationship between spatial skills and math since these tasks require the utilization of both domains in the brain (LeFevre et al., 2013).

Spatial language, using words on, in, under, top, middle, and bottom, enhances cognition by helping children understand complex events and relationships (Simms & Gentner, 2019). It supports spatial skill development and problem-solving (Loewenstein & Gentner, 1998; Pruden et al., 2011), especially during complex tasks (Gentner,

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2003). Spatial language helps children develop a spatial perspective crucial for academic and daily skills (National Research Council, 2006).

Map-using, a more sophisticated representation of spatial orientation skills, is prominent in modern life. While maps help us understand our geographical location better, they also require that we use higher-order cognitive skills. Children who use maps from an early age and have the experience of making simple maps themselves will be able to improve their symbolic thinking skills and readiness in many academic fields, including mathematics (Liben, 2008; Salsa et al., 2019).

Spatial Skills in ECE Settings

Spatial skills, including spatial orientation, are often neglected in early childhood education (Clements & Sarama, 2011b; Sarama & Clements, 2009; Verdine et al., 2017). This neglect is observed in the time devoted to spatial skills in preschool curricula (Sarama & Clements, 2009) and the emphasis on spatial skills in early childhood teacher education (Ginsburg et al., 2006). For example, in Turkey, spatial skills comprise only 2% of the learning outcomes in the National Early Childhood Curriculum (Ministry of National Education (MoNE), 2013), resulting in an inadequate basis for the intentional teaching of spatial reasoning.

The difficulty in assessing spatial skills is another reason for neglecting spatial experiences in early childhood curriculum (Pollitt et al., 2020). Spatial skills involve mental processes that cannot be seen directly. Their assessment is carried out by experts and using various formal tools (psychometric tests) (Frick et al., 2013; Lowrie et al., 2016). Therefore, it is difficult for teachers to assess children's spatial skills with the resources they have at hand. As a result, most early childhood teachers need to gain knowledge and skills or help to teach spatial skills (Clements & Sarama, 2011a; J. Lee, 2010; J. E. Lee, 2017; Markovits & Patkin, 2020).

Few professional development (PD) programs cover spatial skills (Moss et al., 2015; Simpson & Linder, 2014), and limited research explores teachers' perspectives on these programs (Moss et al., 2015; Sarama et al., 2017; Wilson et al., 2013; Zhang et al., 2021). To address this gap, we developed a PD program to enhance early years teachers' spatial orientation knowledge and facilitate young children's skill development.

Developing a Professional Development Program

Within this program, we aimed to equip teachers with the skills to teach spatial orientation skills autonomously. To accomplish our objectives, we conjectured

that Learning Trajectories (LT) could guide teachers' instruction. They offer structured developmental pathways for teaching spatial orientation skills and incorporate activity ideas to facilitate children's progression through each stage (Clements & Sarama, 2014; Maloney et al., 2014; Sztajn et al., 2012). LT is a road map for teachers to determine children's baseline level, where to start training, and what path to follow. It also systematically addresses the development of children's mathematical thinking based on scientific data (Blanton et al., 2015). Therefore, LT for spatial orientation (Clements & Sarama, 2021) guided us to build an informal assessment tool, a staged set of goals, and activity ideas meeting each goal.

We implemented the PD program while conducting a qualitative research study to learn more about early childhood teachers' experiences participating in the program. Our objective was to contribute to research efforts exploring ways to improve PD programs that help early childhood teachers gain knowledge and skills to teach spatial orientation skills effectively. To accomplish this, we addressed the following research question:

What perceptions and experiences are expressed by the teachers regarding their participation in the professional development program?

In the subsequent sections, we will describe the details of the program, explain the process undertaken, and present our results, discussions, and conclusion.

The Assessment Tool: Learning Trajectories Spatial Orientation Checklist (LTSOC)

After thoroughly examining the stages of developing spatial orientation skills, we developed the LTSOC, specifying the behaviors that act as indicators of developmental stages in LT (Clements & Sarama, 2017, 2021). The contribution of teachers shaped the tool during the process, and the skills were divided into more understandable and smaller steps. There were nineteen skills on LTSOC, ordered from the most basic to the most complex. About two activities were used for each skill, so at least 38–40 activities were implemented within the scope of this research. LTSOC was first used to explain the stages of spatial development while giving in-service training to teachers, followed by the first evaluation of students and the shaping of teaching and purposeful assessment during the project.

A sample of the spatial orientation skills in LTSOC is as follows:

- The child can use the words “in front of” and “behind” by referring to an object.

- The child can use the words “on the right” and “on the left” by referring to an object.
- The child can find an object when described.
- The child can predict the intersection point of two moving objects, one situated horizontally and the other vertically, on a grid-shaped plane divided into squares.

Incorporating Clinical Interviews

Embedding clinical interviews into teaching mathematics has demonstrated its effectiveness in supporting teachers' content knowledge, instructional abilities, and confidence (Ball et al., 2008; Clarke et al., 2011; Moss et al., 2015). Interactions with children allow teachers to identify misconceptions and areas necessitating additional support and shape the instruction to address children's specific learning needs (Jacobs et al., 2010). Moreover, clinical interviews provide teachers with tools to access students' conceptual understanding and capacity to express mathematical concepts and reasoning (Ginsburg, 1997).

Therefore, we conjectured that incorporating clinical teacher interviews would benefit our study. The teachers were required to perform clinical interviews with children to determine their skill levels. They planned the interviews in collaboration with our research team. Then, the teachers independently administered the interviews to evaluate the children's performance in the skills listed in LTSOC.

General Features of the Program

Instructional Activities. The activities were initially drawn from current research-based documents (Clements & Sarama, 2017; Liben, 2008; Moss et al., 2016; Newcombe, 2013; Uttal, 2000). We initially developed a few research-based instructional activities to help children progress along LT. Then, we continuously developed, implemented, and revised the activities with the teachers. After about a month, the teachers collaborated more actively to create new instructional activities.

Some activities were videotaped and shared with mathematics education and early childhood education researchers for expert opinion. The experts noted that the activities and LTSOC were appropriate for teaching spatial orientation skills. Furthermore, the researchers presented a project summary with sample classroom videos at an international conference (K. Koç & Y. Koç, 2019). A world-renowned early mathematics education researcher watched and commented on the videos during the meeting. He concluded that the activities were “authentic” and found them worthwhile for supporting spatial orientation skills (personal communication, November 23, 2019). A sample of our activities with videos and images is available on Hansel (2021) and the

Learning Trajectories website (Clements & Sarama, 2017).

As the activities were designed, we developed games where children could learn and exhibit their spatial orientation skills. A mixture of individual, small-group, and whole-group activities was developed. Care was taken to ensure that the activities possessed the following characteristics:

- Having proper instructions for children to show the skill specified in LTSOC
- Having a game format, including drama or movement
- Relying on the use of accessible materials in the classroom
- Having a workable format compatible with teachers' professional habits.

Whole Group Activities. Our initial observations showed that teachers preferred whole-group activities more due to limited assistance and time for individual learning. For that reason, we developed whole group activities where children's unique learning needs were met, especially the ones who learn at different levels (Birnie, 2015; Tomlinson, 2014). In such activities, children took turns, and each child received different instructions. The teacher gave each child a challenging but achievable task and provided scaffolding through hints and cues when necessary. The tasks were kept short to maintain focus and engagement.

In collaboration with teachers, we developed an implementation strategy for whole group activities that follow these steps: First, the teacher invited a high-achieving child to participate, followed by a child with lower-level skills, then a few randomly selected children, and finally, another high-achieving child. The teacher offered support through questions like “Take a moment to think? Let us count together?” or “Where do you think you went wrong?” Additionally, *revoicing* or verbally describing children's actions served as a model for all children.

Active Use of Spatial Language. Children were exposed to spatial words daily and encouraged to use those words on various occasions. For instance, teachers referred to the positions of unit squares while playing sudoku using spatial words, asked children questions about the relationships between multiple structures when playing Lego, and encouraged children to describe the designs they had built.

Spatial language skills were directly targeted in the English lesson. Also, teachers integrated spatial skills into the activities they organized in language, music, movement, and science to spatialize the curriculum (Ashton et al., 2020; National Research Council, 2006;

Newcombe, 2017). These practices and the regular training sessions made the program more holistic and practical.

Methodology

Research Design

The researchers aimed to develop a program teachers would readily adopt and utilize. To achieve this goal, the researchers sought to explore teachers' reactions to the program, identify potential implementation challenges, adjust as needed, and gain insights into teachers' overall experiences. We employed the constructivist interpretivist case study approach (Bartlett & Vavrus, 2016) as it was the most suitable for achieving our research objective. This approach highlights the importance of presenting authentic experiences from those who live through them (Schwandt, 2000). The researchers were active participants throughout the current study, acting as the "main instruments" (Stake, 2010, p. 36) to convey a lived experience to the reader with their interpretations. They spent at least 1 day every week in the school for 5 months, held meetings with the teachers, introduced original activity ideas, and observed classrooms to familiarize themselves with the field and to understand classroom dynamics.

The School and Teachers

This study was conducted as part of an early childhood mathematics PD program offered by the researchers at a private kindergarten in Istanbul, Türkiye. The school administration approached the researchers to design a program to enhance the quality of mathematics instruction. Two female kindergarten teachers, Sara and Meryem (pseudonyms), were teaching in the school, and we invited them to participate in the research. Both teachers voluntarily agreed to be involved in this research.

With 27 years of experience, Sara held a 4-year university degree in early childhood. The other teacher, Meryem, had been teaching for 13 years. She had a vocational school degree (the equivalent of high school) in child development and was in her second year of an online undergraduate program in child development. They knew each other well and had developed the ability to work together. Permission for the study was obtained from the school administration, teachers, and parents. In addition, informed written consent was obtained from the teachers and children.

The Children

Of the two groups in which the study was conducted, Sara's class had 15 children (7 girls and 8 boys). The

children's ages ranged between 57 and 70 months (about 6 years), and the average age was 64.7 months (about 5.5 years). Meryem's class had 14 children (9 girls and 5 boys). The children's ages ranged between 49 and 63 months (about 5.5 years), with an average age of 54.2 months (about 4.5 years). The families of most students belonged to the middle-income level, and all the parents were university graduates. Pseudonyms are used as identifiers instead of real-world names.

The Program Content

Implementation of the Program. The PD program continued for 5 months. The researchers developed a three-phase training model based on the active contribution of the teachers (Figure 1). While the first phase covers the necessary planning for the program and pre-assessments of the children, the second phase is the implementations, including professional development activities and teachers' classroom practices. In the last phase, post-assessments and teacher interviews were conducted to evaluate the program's effectiveness.

Before teacher recruitment, the researchers set the goals of the professional development program, designed major activities, and identified the LT for spatial orientation as the guide for instructing children. Later, the researchers conducted a needs analysis based on their observations and field notes (Martin, 2002; Matthews & Lippman, 2020). Then, they organized an initial meeting with the teachers at the beginning of September 2019. As a result, information was gathered about the teachers' current level of knowledge and the extent to which they included spatial skills in their programs. During the entire research process, teachers' opinions were constantly asked when making decisions about the program, and they were active in decision-making and program implementation. The aim of this was to help them embrace the process.

A workshop was organized as a second step to introduce the Learning Trajectories Spatial Orientation Checklist (LTSOC). This process lasted around a week, and one of the researchers mentored the teachers. At the end of the pre-assessment, the teachers and researchers decided which skills and activities the teachers should start using, and the implementation started.

One of the researchers visited the classrooms at least once a week, carried out the initial implementations of the activities, observed the teachers' practices, and answered their questions. Teachers worked collaboratively throughout the study, making joint decisions and consulting with each other when faced with a problem. Close communication between researchers and teachers allowed them to confirm every step of the project and strengthened the reliability of the study.

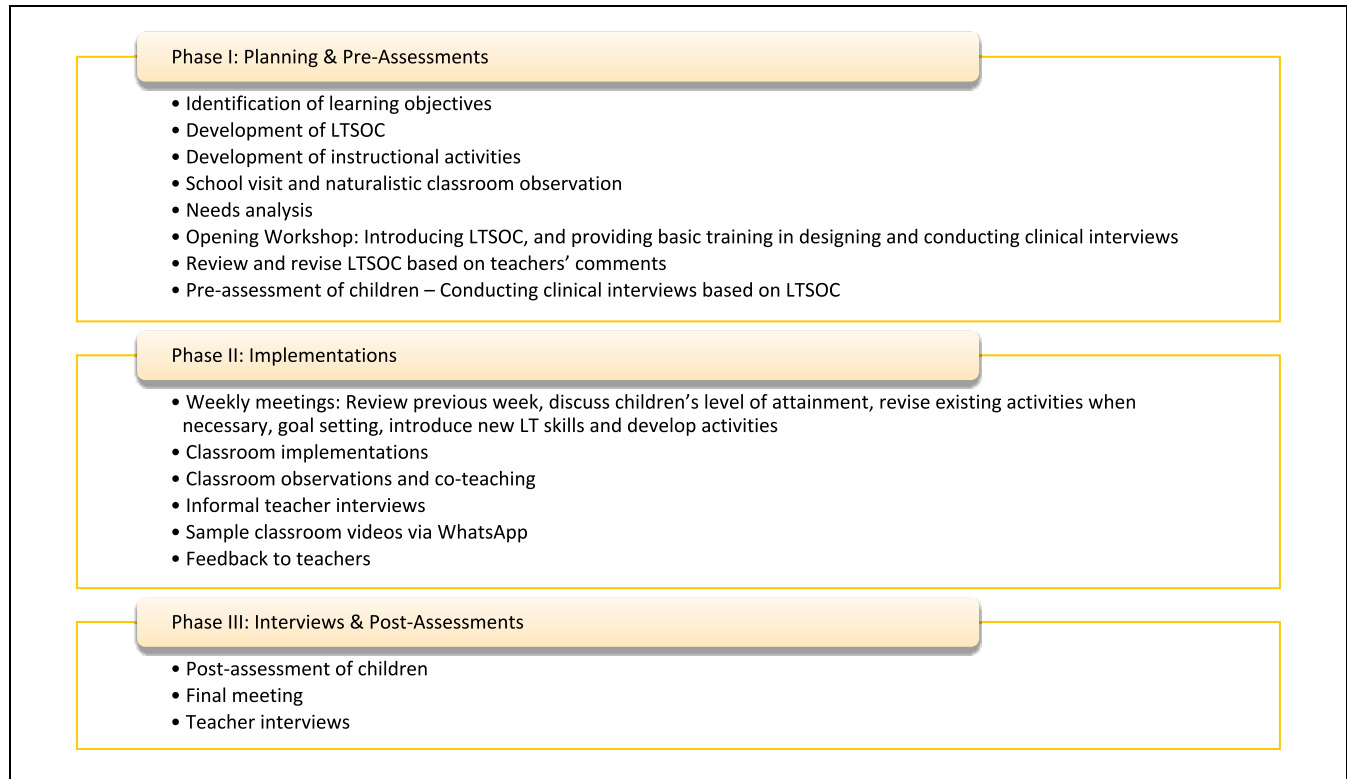


Figure 1. Phases of the professional development program.

The activities were taught for about 30 min a day, and the implementation of map and coordinate activities was extended to a whole week or even longer. The children worked individually, in small groups, or as an entire group. Thus, the teachers implemented most of the activities multiple times. While some of the activities, such as the ones targeting basic spatial terms (inside, on top of, in front of, etc.), took 5 min, making and using the classroom map took about 30 min daily for about 6 to 7 days.

As the children progressed to the next level, teachers were given more detailed information about the upcoming stages of the trajectory, and new activities were introduced. In addition, a WhatsApp group was set up to allow teachers to share activities, pictures, and videos during the week. Teachers were given feedback on this platform, and their questions were answered. In the end, the teachers conducted the post-assessments of the children.

Data Resources

For data collection, we referred to several resources, including (a) field notes, (b) semi-structured individual interviews, and (c) documents written by teachers to provide a rich and detailed understanding of the teachers' perceptions and experiences throughout the professional

development program. Such a combination of methods helped us capture multiple perspectives on the program and to triangulate the data for validity.

Two months into the study, informal interviews were conducted with the teachers, and the process was evaluated. The study ended 5 months later, and an evaluation meeting was conducted. In addition to the weekly informal conversations, semi-structured individual interviews were held with the teachers after completing the project. Each interview took about 40 min. During these interviews, we discussed how the program met the teachers' and their students' needs. Finally, the researchers interviewed the teachers once again a year after the project to explore how they viewed their experience of the project and whether they continued to use the skills they acquired during the process.

Data Analysis

In the present study, we analyzed themes and patterns in the data related to the research question to explore teachers' experiences and accounts of their participation in the PD program. As a suitable data analysis approach, we used Qualitative Content Analysis (QCA) to explore the semi-structured interviews and field notes. QCA assigns coding categories to text units (Mayring, 2021) to make

sense of qualitative data (Schreier, 2012, 2013). Our unit of analysis was a meaningful piece of text which can be a word, sentence, a portion of a page, or words. The categories emerged through multiple close readings of the interview data informed by the field notes. After identifying the themes, we systematically analyzed the data to determine the patterns in the text (Neuendorf, 2017). Then, we coded meaningful texts, compared them against each other, and produced themes by grouping texts with similar meanings for generating codes (Merriam, 2002).

For member checking, the teachers were interviewed individually to discuss whether they approved the findings. The consultations with the teachers showed that there were primarily agreements with some additions or clarifications. The corrections were reflected in the results. Additionally, for validity, the researchers interviewed a qualitative research expert not part of the research team about the meaningfulness of their findings and conclusions. As a result of that meeting, it was concluded that the findings correctly reflected the data.

Results and Discussions

Data analysis revealed that participants benefitted from the PD program in various ways and encountered some challenges during the program. In the following sections, we will present and discuss these results.

Benefits

The teachers reported that they had gained valuable experiences and improved professionally. We also learned through follow-up interviews that they continued implementing spatial orientation activities even 1 year after the project ended.

Increased Awareness of Children. Individual differences emerged when teachers conducted task-based clinical interviews and determined which behaviors specified in LTSOC the children could and could not display. For example, when asked to find and fetch items from the classroom next door, some children could do so more efficiently, while others failed. The latter were sent back again with more detailed instructions. Meryem explained this as follows:

Developmentally, we witnessed how much difference even a month could make to understanding instructions. For example, when describing the classroom next door, I used fewer words with mature children but needed to give more detailed descriptions to younger children. For instance, when I said, "Fetch your water bottle from Sara's classroom, near the window," to more mature children, they could do it. However, I had to use more detailed instructions with younger children, such as "You know the heating

panel you see when you enter the next classroom? There is a cupboard in front of the heating panel. Can you bring me your water bottle from the closet?"

According to this data, teachers could see the developmental differences between children more clearly at the end of the assessment. When teachers gave a single instruction containing spatial information to more mature children, they could achieve the task. However, the teachers used instructions containing more detailed spatial words describing each step for less grown children. Previous studies show that when tasks are complicated and children need support to grasp the situation, using spatial language facilitates and accelerates children's task completion (Gentner, 2003; Loewenstein & Gentner, 1998). We also observed that children needed support from spatial words when they had difficulty doing the task.

Teachers also began to see connections between the characteristics of children and their educational profiles. For example, children who just started school displayed lower-level skills in LT than their peers, regardless of age. Therefore, the teachers brought these newcomers up to speed with the rest of the class. In addition, the teachers observed that younger children tended to have low-level skills, which could be due to parental indifference or family problems. By considering such information, teachers gained a higher awareness of children.

The teachers also grasped children's traits better. To illustrate, some children got bored more easily and became attracted to different activities even though they had better preparedness and grasp. On the other hand, some students learned more slowly but were ambitious and devoted their time to a single activity, striving to understand. Teachers observed individual differences during the project and factored them into their activity plans.

Improvement of Spatial Skills and Transfer. The teachers were pleased to observe the children's spatial skills improvements. In addition, most children enjoyed group games and especially enjoyed receiving challenging instructions and solving problem situations in games. The teachers were also tracking the progress of children on LTSOC. According to family feedback, some children played similar games at home, carrying the language they used at school and the skills they learned to their home environments. Meryem said:

For example, Bora's mother said that when a toy is on the carpet, he tells his mom, "Be careful, do not step on it, go right. He sounds like an adult... you know, parents sometimes do not expect children to understand these. However, when they are taught, they can learn everything." The parents saw this, so they liked the process.

Meryem reported that another student invited his mother to play games with him at home, and then he took on the role of teacher and made his mother play games like the ones he played at school. She realized the change in children's speech at home and school with their parents. Children began to pay more attention to the positions of objects in space and used spatial language to describe them.

Sara thought that this training increased students' attention, improved their observation skills, and noticed more details of objects around them. She noted:

Children's observations have changed..., while they previously had limited drawing and observation. They were making much broader, much more comprehensive observations. For example, when we went to the garden, Melisa said, "My teacher, this is a thorny tree, its leaves." Before that, the child did not know that much. Then she found a fig tree leaf and said, "Look, teacher. Look how wide it is and has so many veins. The thorny pine tree has no veins." This started to develop after that (spatial training). Children's observation skills improved. They began to make more detailed observations.

She also believed that due to this education, students learned letters of the alphabet more quickly than those in previous years. In addition, she hypothesized that students who could describe the locations of objects using spatial words also learned writing more rapidly when they referred to letters by using similar words. For example, when learning to write the letter "I," the children quickly followed instructions such as "Now let us draw a line from top to bottom."

Professional Development and Recognition. Both teachers stated that their knowledge increased during this study. Meryem believed that what she learned improved her professionally. She also said that knowing the scientific foundations of the practices made her embrace this project more.

Additionally, the teachers' work was recognized and appreciated. When the students excel in spatial language and other math skills, these developments attract parents' attention, most of whom mentioned the changes they observed and expressed their satisfaction to the teachers. Along with the parents, the school administration also gave positive feedback to the teachers, which pleased them.

As the teachers had more comprehensive information on the subject, they mentioned the scientific data to the parents when discussing curriculum contents. As a result, they thought the parents had more respect for them and felt increased professional prestige. Sara said the following:

When I began to work with you, I started to understand the science behind the topic and became able to express myself in a better-planned and more straightforward way. You speak with more data, and the parents think, "This teacher is very well-equipped. She knows both the background and the practical work with the child." Once parents see their children's growth, they develop even more respect for the teacher.

Transforming Teaching Practices. Both teachers stated their satisfaction with the project. There were several reasons for this. First, receiving guidance during the teaching process increased their professional comfort. They did not have to make decisions independently and could consult the researchers whenever they were in doubt. Also, they could easily reach the researchers on WhatsApp and ask their questions. They often made short videos of their work and sent them to the researchers for feedback.

They also became more planned and organized, could observe the children better, and saw their improvement. Reflecting on her experiences in the PD program, Meryem highlights its positive impact on her teaching practices:

It made things more manageable regarding getting to know the children. So, in terms of what we can provide for the children, it is a facilitating and supportive factor.

Meryem's reflection underscores the value of the PD program in providing her with the tools needed to enhance children's learning experiences.

LTSOC chart helped them decide what to teach and in what order. The assessment also became more manageable. According to the teachers' statements, they needed to ensure they knew the children and their learning difficulties before using the LT chart. When they saw a deficiency, they prepared activities independently but found teaching children skills without LT challenging. Sara said, "I did not know there was a certain order I had to follow." Determining what to teach became much easier for her with LT. Sara added,

It (LTSOC) was very beneficial. I would have had to research this myself: Which one should I teach first? This was such a comfort for me. You lightened my burden by giving me this table. You were very supportive.

In the above quotation, Sara highlights the benefits of LTSOC, such as its convenience and the comfort it provides by streamlining her decision-making process. Additionally, she acknowledges the support provided by the researchers, as it reduced her workload and allowed her to focus more effectively on teaching.

Unlocking Learning Potential. Teachers pointed out that LT mainly benefits children with special needs. However, they did not think of special education only as education for diagnosed children. All children who learned slower than others due to genetic, familial, or environmental factors needed special attention. According to the teachers, using LT made things easier in such situations. When a child could not display a particular skill, assessing him was much easier using LT. Meryem referred to this as follows:

I may have ignored teaching this skill in the first place. Alternatively, I may have yet to observe the child and overlooked it at the time. However, when I use this form for assessment, it becomes a guide.

LT also guided them as they started teaching after the assessment phase. Skills in LTSOC became targets for the teachers, allowing them to teach in a specific order. They found that children learned more quickly when skills were introduced in order. These results were unsurprising, as teachers in other LT studies commented similarly (Sarama et al., 2017).

Sustainability of Professional Development. At a follow-up interview 1 year after the completion of the study, one of the teachers was working in a different institution while the other was still working at the same school. In the interviews, both teachers stated that they continued the practices after the project and that their teaching became even more fruitful the following year. Meryem pointed out:

We indeed continued to apply what we learned during the project. First, I realized that I also needed to use spatial language, such as “right,” “left,” and “above,” while speaking. So, we changed our way of speaking and implemented similar activities with variations. We continued using the puzzle mat for our activities. In daily routines, I intentionally used spatial language; for instance, I would ask the children to move to the right, front, or back of the line while walking to lunch. I have used the knowledge and experiences gained from the project ever since.

Meryem indicated that she was still using spatial orientation activities and spatial language even after the project ended. Sara also continued implementing the project activities. For example, she noted, “I am conducting the work you introduced at my (current) institution here.” She also added,

I did everything you showed me and even more. As a result, I got great results this year. I also received very positive feedback from the parents.

Sara has successfully applied the techniques beyond what was shown, leading to significant results in her new workplace. In addition, the parents’ positive feedback validates the effectiveness of her teaching. This and other teacher remarks reflect the sustainability of teacher learning following the PD program.

Challenges

Our data indicated that the teachers experienced challenges implementing what they learned in the PD program. However, the data also shows that the teachers, with the help of the researchers, used effective strategies or adaptations to overcome those challenges.

Challenges in Implementing Learning Trajectories for Spatial Skills. Initially, the researchers hypothesized that introducing the entire PD content at the program’s onset would be challenging and burdensome for the teachers to understand spatial orientation skills formation. Hence, they decided to explain a small section at a time while introducing more complex skills as the teachers progressed through the program. The teachers expressed satisfaction with the process in the interviews we conducted during the implementation phase of the study. However, we observed issues in teachers’ assessment of the initial performance level of their students. For example, assessment records showed that a few students skipped lower-level skills and reached higher levels, which is developmentally unexpected. Although such incidences were limited to a few cases, they indicated teachers’ limited comprehension of LT. In addition, a few items in LTSOC included more than one skill, preventing teachers from understanding and assessing them effectively. Upon receiving this feedback, we discussed the items with the teachers, simplified the skills, and divided some items into more components.

Reflecting on the study in the 1-year follow-up interview, both teachers said it was necessary to have an overview of activities at all levels of LT at the beginning of the program and see the big picture to provide a better assessment and instruction. They reported that they felt more comfortable making plans and could think more comfortably and multidimensionally with their knowledge and experience 1 year later. For example, Meryem said,

This study made things easier for us. The only challenge for me was that this was our first experience with this kind of work. If we had worked on its background with you and you had provided us with the full training and information at the beginning, it might have been much more helpful for us.

Her remarks highlight the program's benefits while acknowledging the importance of adequate support and preparation for teachers.

Sara highlights,

I struggled because I did not know the next step well enough. However, this year, I did not struggle at all, and it was easier to implement because I knew what the next step would be.

Challenges in Conducting Clinical Interviews. Another challenge was the difficulty of conducting clinical interviews for two teachers who needed a professional background in the subject. The teachers examined the behaviors specified in LTSOC and determined tasks that would elicit these behaviors. Those tasks included skills like asking the child to find a hidden item or to hide it and describe it to friends. The teachers observed children's behaviors as they performed these tasks, asked questions when necessary, and tried to understand what, why, and how they did what they were doing. Sara explains this as follows:

While giving instructions, I needed to tell them what to do briefly. So instead, I deliberately talked at length. This is because I wanted to push them a little. I did this to see whether they understood my instructions fully or not and whether they complied by chance. Also, I kept changing the instructions for each child because they imitated each other by repeating the same sentences.

Thus, they attempted to determine whether the children could follow simple instructions. They realized most children could understand spatial words, but this assessment was only reliable sometimes. In some cases, for example, children could fetch an item from a particular location in the classroom, not because they understood the instructions but because they already knew where the item was located. In other words, the children used *practical or perceptual knowledge* rather than *conceptual understanding* (Newcombe & Huttenlocher, 2000). As a solution, the teachers agreed to instruct the children individually to fetch a specific item from the other classroom. For example, the children were asked the same question at different intervals, in different environments, and diverse ways (Ginsburg, 1997). This was manageable if the students were prepared or had already acquired that skill, but it required a longer time to determine the level of the children with lower maturity (Wang, 2010). This assessment was vital in identifying suitable activities. However, teachers had difficulty finding and asking appropriate questions to determine whether a particular skill existed and sometimes needed the support of researchers. However, as they gained experience in the process, they became more adept at asking appropriate "probing" questions that would allow the students to show their understanding. As in Moss et al. (2015), the

interview process provided the teachers with rich experiences and enabled them to help the students when needed.

Challenges in Engaging Young Children in Structured Activities. The teachers were drawn to another issue that arose during the project implementation. While most children and their families were content with the activities, a few students shared a different sentiment. Some families contacted Meryem, expressing their concerns that their children were feeling uninterested and did not want to attend school. These students had informed their parents that the teacher always made them play tedious games instead of allowing them to play independently. Meryem commented:

My class was younger. There were new school goers. They were reluctant to participate not only in these activities but in, for example, physical education as well. Such games (played with teacher instructions) made them feel limited.

Thus, guided activities could have been more appealing to those children. She also added that they were not inclined to follow the rules at school and home. Therefore, the present research showed that children who were developmentally ready and accustomed to the school culture benefited from the program more.

Conclusion

In this study, we implemented a professional development program based on the principles and stages of the learning trajectories for spatial orientation to support two teachers' teaching quality. They were allowed to expand their understanding of spatial orientation skills, observe students, exchange thoughts with others on educational matters, and, most significant of all—control the process according to their situation, children's needs, and classroom culture while making necessary adaptations. The program was flexible because it allowed the participants to use various materials and techniques at their own pace and based on children's needs. Flexibility was essential to form and implement a successful curriculum (Vreuls et al., 2022).

The researchers supported the project, including positive, encouraging, and specific feedback (Berner et al., 2022; Gabelica et al., 2012). However, it was essential for teachers to offer their ideas, comments, and insights. This involvement may have facilitated their adoption of the program (Bayar, 2014; Desimone & Pak, 2017; Loucks-Horsley et al., 2009). Consequently, the teachers integrated the LT as an effective tool into their lesson plans that they proceeded with even after the project ended.

Participating in this study has impacted teachers' and children's lives. The teachers began to understand the subject matter's significance and noticed changes in children learning. They could also observe how spatial orientation skills shaped children's behaviors, improved their observation skills, enhanced their understanding of the subjects across the curriculum, and—one of the teachers claimed—helped children advance their literacy skills. Future research may explore the effect of spatial orientation skills on different developmental areas and abilities.

Additionally, the teachers observed that incorporating LT enhanced their professional decision-making. They discovered that following a structured approach to delivering specific experiences could be an effective and time-saving solution while also making them feel more at ease in the classroom. Nevertheless, teachers needed to gain ample exposure to apply for this LT program independently.

The reasons for the program's success from the teachers' perspective can be considered in two groups: The first covers the PD program's features. The prominent features of the program are (a) teachers were allowed to teach and receive regular feedback, analyze student work, and revise their plans; (b) PD activities were spread out over a semester with more than 20 hr of contact time; and (c) the teachers were provided with the flexibility to share ideas, collaborate, and support each other. In addition, our participants were part of a team where they discussed their educational practices that nurtured their professionalism. These features have widely been recognized as characteristics of effective teacher professional development efforts (Bayar, 2014; Borko, 2004; Darling-Hammond et al., 2017; Desimone, 2009, 2011, 2023; Desimone et al., 2002; Loucks-Horsley et al., 2009).

The second group of reasons for our PD program's success centers on the program's content: Spatial orientation skills and Learning Trajectories (LT). The LT approach (Clements & Sarama, 2021) was successfully adapted threefold: as an assessment tool, curriculum guide, and differentiated instruction guide. As an assessment tool, the Learning Trajectories Spatial Orientation Checklist (LTSOC), with the most basic to the most complex skills, helped teachers assess children's levels. In addition, each skill in LTSOC was well-defined and supported with a brief teaching idea. These features of LTSOC were helpful for the teachers to design activities for eliciting the relevant skills, especially for children with diverse needs, as in previous studies incorporating LT for other strands of mathematics (Sarama et al., 2021).

While the study reports positive effects of spatial orientation skills on children's learning, it did not provide empirical evidence. Future research could further explore this aspect. Additionally, the sample size is

limited to two kindergarten teachers. Future studies could involve more teachers providing a broader understanding of the PD program's impact.

Besides the multiple benefits, we have also discovered that teachers experienced a few challenges while implementing the program in their classrooms. To overcome such challenges, we recommend that teacher educators provide a comprehensive overview of the program's content, and a workshop on conducting clinical interviews to help teachers feel more comfortable in carrying out the program.

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Author Contributions

Both authors prepared, read, and approved the final manuscript.

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Ethical Approval

This research was reviewed and approved by the Kocaeli University Graduate School of Science and Engineering Ethical Review Board on February 15, 2019 (# 10017888-050.99). All ethical standards were followed throughout the research procedures.

Informed Consent

Informed written consent was obtained from the participants.

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Availability of Data Material

The or analyzed during/or analyzed during the current study are not publicly available to protect the identities of participants but some de-identified data may be available from the corresponding author on reasonable request.

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