

# Introducing spatial thinking and lesson study: Researcher's role in early childhood story-based design integration

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## Abstract

**Purpose** – This study aims to investigate how a researcher supported early childhood (EC) educators in integrating spatial thinking into the curriculum through lesson study (LS). It was conducted in a context where both LS and spatial reasoning were unfamiliar. The study explores the facilitation strategies that initiated and sustained teacher dialogue about case pupils' spatial thinking. It further examines how these strategies contributed to professional learning across dimensions of satisfaction, knowledge, instructional practice and school-level change.

**Design/methodology/approach** – A qualitative case study approach was used, drawing on audio recordings of LS meetings, pupil artifacts, researcher reflections and field notes. Reflective thematic analysis traced how the researcher scaffolded teacher thinking and interaction across LS phases, with particular attention to discussions focused on case pupils' spatial reasoning.

**Findings** – Researcher support evolved from directive reassurance during the workshop to more facilitative prompting as teacher confidence increased across the LS cycles. Key mechanisms included reassurance, strategic questioning, mindset reframing and structured protocol for debriefing session and observation sheets to anchor discussions in pupil learning. Constraints such as staffing shortages and LS unfamiliarity were addressed with adaptations in the LS process.

**Practical implications** – Findings inform LS facilitation training by emphasizing gradual autonomy, structured reflection and teacher-led inquiry. The study also offers guidance for sustaining LS in under-resourced settings.

**Originality/value** – The study offers new insights into multi-role LS design and facilitation in EC education, especially for unfamiliar areas like spatial thinking. It shows how researchers can support teacher learning and facilitate processes that make such content visible, actionable and embedded in classrooms.

**Keywords** Early-childhood (EC) education, Spatial thinking, Teacher learning, Professional development, Lesson study (LS) adaption, Facilitation

**Paper type** Research article

## 1. Introduction

Spatial thinking is a fundamental aspect of cognitive development, particularly in early-childhood (EC), as it lays the groundwork for critical skills in STEAM (Science, Technology, Engineering, Arts, and Mathematics) education (Hawes *et al.*, 2023; Yang *et al.*, 2020). It refers to the ability to understand locations, shapes, object relationships, and movement

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through space (Newcombe, 2017). Early-childhood STEAM education provides fertile ground for fostering spatial skills, as young learners begin to explore and experiment with construction materials (Pritulsky et al., 2020).

Despite international efforts in Europe, Australia, and the US to embed spatial thinking in classrooms, sustainable implementation is rare. A key barrier, as noted by Newcombe (2017), is the limited attention given to spatial reasoning in curricular standards. As a result, teachers face both conceptual and structural barriers when adopting such practices. For example, they often express uncertainty about children's capacity for spatial reasoning and creativity. In addition, EC educators typically teach across multiple subject areas (Foster and Trundle, 2024), making it difficult to focus consistently on spatial skills. Time constraints and competing demands further limit teachers' opportunities to trial new content or pedagogical strategies (Hourigan and Leavy, 2024). Moreover, some EC educators may have lower spatial ability or experience spatial anxiety (Atit et al., 2018), which can diminish their motivation to include spatial tasks in their teaching practice.

Here, story-based design can help integrate spatial thinking into STEAM for EC educators (Kharbanda and Khunyakari, 2025; Mishra et al., 2025). Storytelling offers meaning, context, relevance, and empathy (Haven, 2007) and can enrich spatial concept development through embodied role-play (Fleer, 2022). This study aligns with Pritulsky et al. (2020) in embedding spatial language, gestures, and tasks into daily classroom practice. To facilitate this potential, we draw on Lesson Study (LS) as conceptualized by Lewis and Tsuchida (1999), who describe a shift from "teaching as telling" to "teaching as understanding." They emphasize that research lessons allow teachers to explore new instructional approaches within their daily routines, helping to link classroom practice to broader pedagogical goals. Lesson Study integrates standards, teacher learning, and curriculum enactment (Dotger and Walsh, 2015); supports reflection and systemic improvement (Dudley and Vrikki, 2019); and fosters collaborative curriculum change and school culture (Vermunt et al., 2023), making it especially relevant for early-childhood education. This study explores how researchers can design and facilitate Lesson Study processes that make emerging content areas like spatial thinking, visible, actionable, and embedded in EC classrooms.

## 2. Literature review

### 2.1 Challenges of implementing lesson study (LS) in early-childhood (EC) classrooms: the Researcher's role

Facilitating LS in EC contexts presents unique challenges that heighten the importance of the researcher's role. Traditional LS processes often revolve around a research lesson with clear objectives and observable outcomes. However, this model does not always align with the fluid, play-based nature of EC education (Foster and Trundle, 2024; Clivaz et al., 2025). For instance, EC classroom research lessons often lack the structure of primary or secondary lessons, making it difficult for observers to "see" or "hear" pedagogically significant moments in real-time classroom settings (Foster and Trundle, 2024). Facilitators must therefore help teachers prepare to recognize and respond to emergent learning opportunities during play-based activities (Clivaz et al., 2025).

Furthermore, Helmbold et al. (2021), emphasize the need for LS in early years to shift from a diagnostic assessment of learning gaps toward a conceptual focus on what and how concepts should be taught. This subtle but significant shift demands more from the researcher-facilitator, who must support teams in navigating ambiguity and co-constructing goals despite limited formal assessment data. Additionally, EC teachers may lack experience in articulating research questions or reflecting on young learners' learning trajectories (Foster and Trundle, 2024) requiring extra scaffolding from the researcher. Another persistent challenge is the availability of external expertise, commonly referred to as the "knowledgeable other." Although essential to authentic LS, such experts can be difficult to identify and fund (Takahashi and McDougal, 2016; Foster and Trundle, 2024).

Adapted LS models must also account for the developmental characteristics of early years education, where observation, imagination, and child-initiated activity are central (Foster and Trundley, 2024; Clivaz et al., 2025). Facilitators must help direct teacher discussions toward children's perspectives and observable behaviour, allowing teachers to shift from focusing solely on classroom activity to broader professional reflection (Aas, 2020).

### 2.2 Design and facilitation in adapted lesson study: extending the Researcher's role

Researcher's role is especially crucial in settings where teacher-led research cultures are still emerging or where professional development resources are limited, such as in rural or under-resourced contexts (Flanagan et al., 2024). Researcher in a role of facilitator must also carefully balance instruction with autonomy (Lewis, 2016). Helmbold et al. (2021) note that over-instruction can stifle teacher agency, while under-supporting can lead to confusion and disengagement. Although researchers bring evidence-based insights into the LS process, they must avoid slipping into evaluative or directive roles (Clivaz and Clerc-Georgy, 2021). As such, the researcher-facilitator must cultivate trust and provide space for teachers to explore uncertainties, initiate ideas, and solve instructional challenges collaboratively. This balancing act is particularly delicate in EC settings, where research questions may be abstract and observational data inherently interpretive. Clivaz and Clerc-Georgy (2021) emphasize that facilitation roles are fluid, evolving with team dynamics and the progression of LS cycles. Dual facilitation models such as pairing a pedagogical expert with a content specialist have proven effective in adapted LS contexts (Clivaz et al., 2025). However, such models are often impractical in smaller or resource-constrained settings. In these cases, researchers must be prepared to adjust their roles dynamically, sometimes offering direct suggestions, other times stepping back to allow collective sense-making (Uffen et al., 2025). Researcher-facilitators must prompt teachers to engage with academic literature and curriculum materials, as this engagement is not automatic (Choy and Lee, 2021). Facilitators must actively stimulate the desire for new knowledge through inquiry-based questioning and by offering accessible resources (Koffeman and Snoek, 2018).

### 2.3 Researcher strategies for integrating new content into the curriculum

The success of LS hinges on specific facilitation strategies that enable teachers to integrate new content areas, such as spatial thinking, into the curriculum. One key mechanism is collective inquiry. Mynott and Zimmatore (2022) argue that authentic collaboration should resemble "joint work" rather than a series of isolated professional exchanges. This requires intentional relationship-building, active listening, openness, and vulnerability in professional dialogue. Kager et al. (2023) argue that LS enhances pedagogical practice through collaborative problem-solving, which depends heavily on skilled facilitation to maintain focus, address emerging challenges, and foster shared understanding.

Another vital element is professional dialogue. Dudley and Vrikki (2019) argue that effective Lesson Study requires practitioner-mediated toolkits to foster safe, evidence-informed dialogues. They advocate for dialogic strategies such as reasoning, challenging, and elaborating to enhance group learning, stimulate hypothesis generation, and testing. Kvam and Munthe (2021) highlight three key strategies for productive Lesson Study dialogue: clarifying pedagogical assumptions, aligning tasks with learning goals, and connecting research with teachers' classroom knowledge.

Creating the conditions for reflective dialogue is equally essential. Lewis (2016) identifies teacher resistance, limited time, and uncertainty as common obstacles for new facilitators. To address these, De Vries and Uffen (2021) stress that trust and openness must precede reflective engagement. This is particularly important in teaching cultures that prioritize expertise and autonomy over collaboration. In this context, Uffen et al. (2025) introduce the concept of "talk about consumption," referring to explicit conversations about the purpose and value of LS. Without these discussions, teachers may view LS as an imposed requirement rather than a transformative learning experience.

In summary, in this context researcher often assumes multiple roles: facilitator, co-designer, and mediator of collaborative teacher learning. This role involves fostering trust, supporting reflective practice, adapting structures to fit EC contexts, and keeping collaborative inquiry central.

### 3. Main research question

How does a researcher support early-childhood (EC) teachers in integrating spatial thinking within the curriculum and facilitate teacher talk about pre-schoolers' spatial reasoning during the initial implementation of Lesson Study?

Sub-Questions:

- (1) What specific researcher strategies initiated or sustained productive talk about case pupils' spatial reasoning between EC teacher pairs?
- (2) How did the researcher's facilitation within the adapted Lesson Study process support or hinder teacher learning across three dimensions of professional development: satisfaction, knowledge enhancement and teaching practice?

This research aims to analyse the role of the researcher in supporting or constraining teacher learning across following levels of professional development: satisfaction, knowledge enhancement and teaching practice (Kager *et al.*, 2023).

### 4. Methodology

#### 4.1 Research design

This study employs a case study methodology involving six classrooms across two Irish schools with ten participating teachers. We adopted a design-based research (DBR) approach (van den Akker *et al.*, 2006). The DBR approach enabled iterative refinement of the adapted Lesson Study (LS) process tailored to EC education. The design was informed by two pilot projects: (1) Dutch pre-service teachers working on story-based spatial tasks, and (2) inquiry-based spatial design corners.

#### 4.2 Data collection

The first author transcribed audio recordings from workshops, lesson planning sessions, and post-lesson reflections. Emphasis was placed on preserving the teachers' original phrasing. From the full dataset, eight key interactions were identified for in-depth analysis. A research team of four members co-analysed these selected interactions. Case pupils were selected collaboratively by teachers during planning, based on teachers' professional judgement of pupils' spatial reasoning and engagement across beginner, developer, and expert levels. These pupils served as focal points using observation sheets, design artifacts, and In-Action Case Pupil Interviews (see Section 4.6) to anchor post lesson discussions.

#### 4.3 Analytical framework and coding procedure

We adopted the Context-Mechanism-Outcome (C-M-O) model as used by Ylonen and Norwich (2013) to guide our analysis. Data were analysed using reflexive thematic analysis (Braun and Clarke, 2022), which views researcher's subjectivity not as a limitation but as a valuable resource for insight. This aligns well with the design-based research methodology employed in our study, where the researcher's evolving understanding and *in situ* reflections actively informed theme development. A theme was defined as "a coherent and meaningful pattern in the data relevant to the research question" (Clarke and Braun, 2013). Coding was conducted in multiple rounds. First, the first author independently coded transcripts of post-lesson discussions, identifying instances of researcher intervention. These were categorized into lower-level codes representing different aspects of the researcher's role, including the

facilitation cues and moves used in various LS discussions and dialogues. Interactions reflecting a range of these themes and aligned with our research questions were then selected for collaborative analysis.

We used a co-analysis approach supported by context mapping (Visser *et al.*, 2005) to collaboratively develop interpretations that addressed our research questions. Initially, all researchers independently coded selected interactions into thematic categories. These themes were then discussed and refined through group meetings until a shared interpretation was reached for each episode. To enhance trustworthiness and mitigate facilitator bias, two external researchers shared their interpretations first, followed by those of the second and first authors.

4.4 Ethical considerations

This study received ethical clearance from the Human Research Ethics Committee at hosting institute of the authors. All participants provided informed consent prior to data collection, ensuring voluntary participation and adherence to ethical research standards.

4.5 Context and participants

The context was shaped by Ireland’s recent emphasis on integrated STEM in early years (Flanagan *et al.*, 2024), offering a timely opportunity to introduce spatial thinking through story-based design activities. The study involved ten female in-service teachers, each with between 4 and 15 years of teaching experience. All participants taught Junior and Senior Infant classes (pupils aged 4–6) across two primary schools in Ireland with limited availability of observing teachers (See Table 1). Class sizes ranged from 20 to 25 pupils.

Table 1. Teacher participants and adapted lesson study process

| Teacher participants (pseudonyms) |                                                        |                                           |                                               |
|-----------------------------------|--------------------------------------------------------|-------------------------------------------|-----------------------------------------------|
| Classroom 1                       | Classroom 2                                            | Classroom 3                               | Classroom 4                                   |
| Ms Cassidy<br>Ms Nelly            | Ms Nelly<br>Ms Cassidy                                 | Ms Aine<br>Ms Michelle                    | Ms Jane<br>Ms Rose                            |
| Adapted LS process                |                                                        |                                           |                                               |
| Phase of adapted lesson study     | Teacher development level (Kager <i>et al.</i> , 2023) | Key activities                            | Outcomes                                      |
| 1. Work-Shadowing                 | Insight into Current Practices                         | Classroom Observations                    | Understanding Baseline Practices              |
| 2. Workshop                       | Level 1: Satisfaction and Acceptance                   | Introductory Workshop                     | Teachers’ Acceptance of PD                    |
| 3. Lesson Planning                | Level 2: Knowledge Enhancement                         | Collaborative Lesson Planning             | Developing Spatial Tasks                      |
| 4. Implementation                 | Level 2: Knowledge Enhancement                         | Teaching and Observing                    | Gathering Data on Teaching Practices          |
| 5. Reflection                     | Shared Cognition                                       | Post-Lesson Discussions                   | Reflecting on Teaching Practices              |
| 6. Adaptation                     | Level 3: Teaching Practice Enhancement                 | Revising Lessons                          | Improved Lesson Plan Implementation           |
| 7. Post-Lesson Discussion         | Shared Cognition                                       | Post-Lesson Discussions                   | Knowledge Sharing                             |
| 8. Final Reflection               | Level 4: Organizational Change                         | Collective Feedback and Knowledge Sharing | Proposing Changes in School Structures for LS |
| Source(s): Authors’ own work      |                                                        |                                           |                                               |

As part of an EU Horizon project named SellSTEM, the first author was seconded to a teacher education institute in Ireland to develop and deliver a PD program to integrate spatial thinking in EC classrooms. Schools were selected through consultation with principals and the training organization. Both participating schools were new to LS and spatial thinking.

#### *4.6 Adaptations to lesson study model*

To suit EC classrooms in rural schools, the traditional LS model was adapted in five key ways:

**Work Shadowing:** The researcher spent a day in each participating classroom to build rapport and understand local teaching practices. This informed the initial workshop on spatial thinking.

**Small LS Teams:** Given staffing limits, LS was done in teacher dyads with the researcher. Such tandem building can enhance teacher self-efficacy in EC contexts (Reyhing and Perren, 2021).

**Material Study (Kyozei Kenkyu):** Teachers discussed material use during the lesson planning phase after the workshop. Although additional resources were provided, in-depth study of teaching materials was not included in data due to time limitations.

**Facilitated Post-Lesson Discussions:** A researcher-facilitated semi structured reflection to focus talks on spatial thinking development of case pupils.

**In-Action Case Pupil Interviews:** Interviews were embedded within classroom design activities to better capture young pupils' thinking as it unfolded.

**Online Reflection Meetings:** Instead of public lessons, teachers reflected after two LS cycles in an online meeting. This enabled inter-school collaboration and included stakeholders such as principals and the teacher training institute director.

In addition, teachers initially struggled to formulate a research focus due to unfamiliarity with spatial thinking. Thus, teachers started with a broad research theme about how design tasks based on stories help case pupils use spatial language and gestures.

#### *4.7 Role of the researcher*

The first author served as designer, facilitator, and reflective practitioner. They led workshops, supported task design, and guided reflections using observation tools. With over a decade of experience in STEAM teacher-education and three years in Lesson Study, their interventions remained minimal to encourage teacher ownership and focus on pupil learning. The researcher's contributions were informed by previous experience, case studies, training workshops, and professional collaborations.

#### *4.8 Professional development program design*

The PD program followed a structured progression (see Table 1).

**Work-Shadowing and Workshop:** Initial school visits were followed by a workshop introducing spatial thinking through story-based activities. The workshop provided more in-depth knowledge and built on domain-specific pedagogical content knowledge. In groups, teachers selected a story and identified a character with a problem to frame a design task. For example, from We're Going on a Bear Hunt, they created tasks such as crossing a river or mud without getting wet, or designing something to catch the bear.

**Two LS Cycles:** Each cycle included lesson planning, teaching, observing, and post-lesson discussion. Observations were guided by an observation sheet (Appendix A) focused on spatial thinking.

**Online Reflection Meeting:** Instead of a public lesson, an online reflection session allowed both schools to share learning. Following Dudley and Vrikki (2019), this discussion emphasized pupil learning and future instructional adjustments with-in curriculum.

#### *4.9 Post-lesson reflection structure*

Reflections took place immediately after each lesson, lasting 30–40 min, and were documented through audio recordings. Observation Sheet (Appendix A), and questions to

facilitate Post-Lesson Discussions ([Appendix B](#)) are used by researchers. The process followed following steps:

- (1) The observer teacher initiated a discussion on case pupils' spatial thinking progress and instructional needs.
- (2) Class teachers reflected on learning outcomes, challenges and assessment.
- (3) The researcher intervened only when invited, maintaining teacher-led dialogue.

Each debriefing session involved two teachers and the researcher. This structure promoted focused discussion on student learning, not teacher performance. In School A, reflections occurred in the same classroom as the lesson; in School B, they were held in a staff room.

## 5. Findings

Based on our analysis, we present a narrative account that reflects the shared voice of the authors and two external researchers. For clarity, each interaction includes: Context (the situation and teacher challenges at that phase of Lesson Study), Interaction Transcript (verbatim dialogue), narrative analysis followed by Mechanism of researcher interventions, and Outcome (changes in teacher thinking or practice). The researcher's facilitation role and interpretations during and after LS sessions were documented through field notes which were used iteratively during coding and theme refinement, making the researcher's reflections integral to the analytical process.

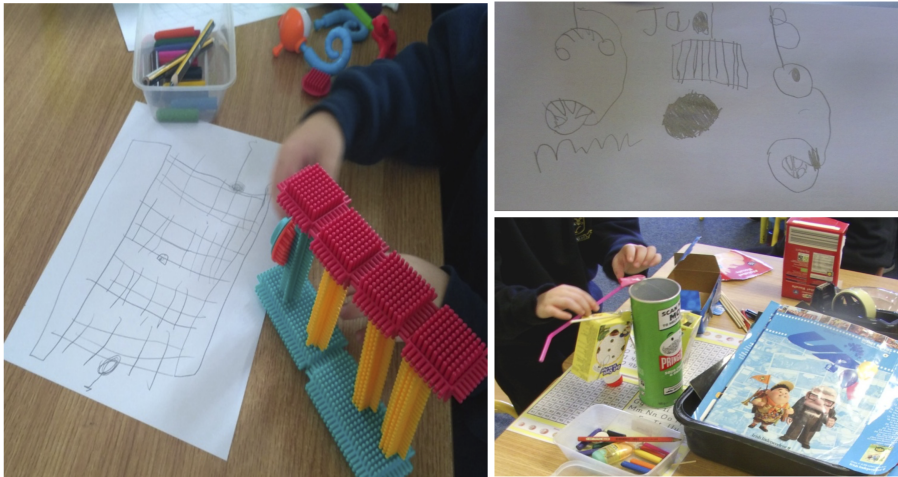
### *Interaction 1. Researcher providing reassurance in Pupils' Sketching Ability*

**Context:** In workshop during the planning phase of a design activity teachers and researcher are discussing the value of sketching.

#### **Intraction transcript 1:**

- (1) Ms Michelle: At this level of junior and senior infants, we're not expecting them to sketch. Maybe older kids might sketch. But these kids gonna get straight into making.
- (2) Researcher: I'm giving the Irish school's perspective here—they can sketch and they did sketch very well (in another school). They will not of course sketch their ideas as they think, but at least their sketches give some ideas, and it's a good thing for you also to see how much they can or cannot do. Like for catching the bear, someone made a jail (showing) this is a strip, a line and three lines. But even in that, there was someone who came up with a mechanical structure with two wheels and a ladder. ([Plate 1](#))
- (3) Ms Grainne: I suppose you're going to be presented with the problem. A child may have issues in the sketching area, and some can't even explain the idea after trying to sketch, because they may have issues with language-so you're meeting barriers all along the way.
- (4) Researcher: Yeah, and you're giving them all these options. So if they can sketch, they will sketch. Some of them can speak up and directly want to go to the materials-they're free to do so.

Ms Michelle expresses doubt that young pupils can sketch, assuming it is beyond their developmental stage (line 1). The researcher responds by scaffolding the discussion through reassurance (line 2), acknowledging challenges (line 2), and providing examples from another classroom where young children successfully used simple or complex sketches to express ideas (line 2) (check [Plate 1](#)). This serves as a counter-example to the teacher's assumption. The researcher encourages teachers to test their pupils' capacities (line 2), fostering a growth mindset. Ms Grainne adds concerns about language barriers affecting sketching (line 3). The



**Plate 1.** Sketches and designs made by pupils, ranging from simple bars of different widths to complex mechanical structures as traps

researcher responds by promoting flexibility in instructional methods, suggesting sketching, speaking, or material use as options (line 4).

Mechanism (Researcher Interventions):

- (1) **Providing Reassurance and Alternatives:** Reframing sketching ability through examples from other schools.
- (2) **Encouraging Growth Mindset:** Encouraging teachers to test what pupils “can and cannot do.”
- (3) **Introducing Flexibility in Instruction:** Promoting multimodal communication for expression.
- (4) **Offering Practical Solutions:** Validating concerns while suggesting that diverse options for design communication through sketch ([Kelley and Sung, 2017](#)).

**Outcome:** Teachers reconsider their assumptions, integrate sketching into lessons, and observe surprising capabilities among their pupils. This leads to a shift in teaching strategies, with a greater emphasis on flexibility and multimodal expression in classroom activities.

*Interaction 2.* Researcher reframing concerns about Pupils’ Creativity in Open-Ended Tasks

**Context:** During the workshop, teachers were preparing an open-ended design task based on the story named *Stuck*.

**Interaction Transcript 2:**

- (1) Ms Michelle: The only problem I see with our *Stuck* story is that they all might just build a ladder. And I kind of don’t want lots of ladders.
- (2) Ms Aine: I think if I just read the story to a certain point and not introduce the ladder (the solution), maybe different pupils will come up with different ways.
- (3) Ms Michelle: Yeah! That’s my concern—it’s really obvious to just do a ladder.
- (4) Researcher: OK, that’s fine. Just to give you an example, all these three pictures have ladders.

- (5) Ms Michelle: But they're different ladders.
- (6) Ms Aine: These are different structures, and making different structures is key if I understand correctly.
- (7) Researcher: The idea of them (pupils) making these structures is that they will come up with spatial language and gestures. That would be our interest.

Ms Michelle was concerned that pupils would all create the same solution, a ladder (line 1), fearing a lack of creativity. Ms Aine proposes a partial story read-aloud to avoid cueing the solution (line 2). The researcher responds by showing three visual examples of ladders (line 4), reframing the issue by emphasizing structural diversity and language use. Teachers accept this perspective (lines 5,6). The researcher then ties the activity's objective to spatial language development (line 7).

Mechanism (researcher intervention):

- (1) **Reframing Concerns:** Showing that similar outcomes can still exhibit creative variation in language.
- (2) **Using Examples:** Providing visuals to support idea diversity.

**Outcome:** The teachers' initial concern about limited creativity was reframed, helping them see the diversity in even similar designs in terms of language and gesture used by the pupil. This clarification reassured the teachers and refined their understanding of the lesson's objective.

*Interaction 3. Encouraging Open-Mindedness About Creativity Under Time Constraints*

**Context:** Following Episode 2, Ms Michelle raises further concerns about creative limitations due to time.

**Interaction Transcript 3:**

- (1) Ms Michelle: So it's OK to have 20 ladders. Whereas with the Gingerbread Man story, I can see more options, someone might build a bridge, a slingshot, or a hot air balloon. But maybe they're too young for that amount of creativity.
- (2) Researcher: Maybe they will surprise you.
- (3) Ms Michelle: Yeah, I can see them thinking it, but making it within the time constraint would be difficult.
- (4) Researcher: I totally agree with your point about time constraints—they might go for the easiest thing. But at this age, copying ideas is actually harder. So you will have the variety for sure.

Ms Michelle doubts that pupils can demonstrate creativity under time constraints (line 1). The researcher offers positive reinforcement (line 2), validating concerns while explaining that young pupils are less likely to copy each other (line 4). This reassures the teachers and supports their decision to try the open-ended task.

Mechanism (researcher Intervention):

- (1) **Encouraging Open-Mindedness:** Suggesting pupils might exceed expectations.
- (2) **Sharing Expertise:** Explaining developmental tendencies in creativity.

**Outcome:** Teachers proceed with open-ended design tasks and observe surprising levels of originality from pupils (check also [Interaction 4](#)). [Plate 2](#) (Right) shows pupils' multiple design other than the solution suggested in the story.

*Interaction 4. Teachers' Surprise at Lack of Copying in Pupils' Designs*



Enhanced construction guided by teachers using gesture and spatial language, keeping the sketch consistent. (Left)



Pupils' original design featuring ladders and diverse solutions to retrieve the kite. (Right)

**Plate 2.** Pupils' initial creative solutions involving ladders and multiple ideas (right), and teachers' guided improvements emphasizing gesture and spatial language while preserving the original sketch (left). Source: Authors' own work

**Context:** Post-lesson discussion after implementing the open-ended design task.

#### Interaction Transcript 4:

- (1) Ms Jane: The children didn't copy each other; they really had their own ideas, which was great.
- (2) Ms Rose: Yeah, didn't you say that before (pointing to researcher)? You mentioned that junior students are less likely to copy. I remember thinking they always copy in maths and other things, so I was really surprised none of them copied each other's design.
- (3) Ms Jane: I was so scared of that when I did the lesson, thinking they'd copy, but everyone was different.

Teachers express surprise that pupils didn't copy each other (Image II, right), validating the researcher's earlier prediction (Line 2). This helped deepen the teachers' trust in the process and encouraged further experimentation.

#### Interaction 5. Researcher's Questioning to steer teacher discussion

**Context:** After the second lesson, researcher guides discussion about the influence of design on spatial language.

#### Interaction Transcript 5:

- (1) Researcher: Do you see any connection between these design or make activities; when it's a specific thing you are making, for example, something to trap? Do you think the objective itself allows them to use more spatial language?
- (2) Ms Nelly: Yeah.
- (3) Ms Cassidy: Oh yeah, I think it does, and to sketch the design is important.
- (4) Ms Nelly: Yeah, I think it would be more focused when they were given a specific task or goal.
- (5) Ms Cassidy: Yeah, more invested in it or something.
- (6) Ms Nelly: I'd say yeah, and then we knew that if we're going to make a trap, they would have to use some sort of spatial language to explain how it works.

The researcher's closed-ended question (line 1) leads to teachers' agreement but limits deeper dialogue. Teachers affirm the link between purposeful tasks and spatial language (lines 2–6), but a more open-ended approach could have led to richer reflection. A more open-ended question (e.g. "How do you think different types of classroom tasks (e.g. design task, role play, free play) impact the children's use of spatial language?") could have led to richer insights and more discussion from the teachers.

Mechanism (researcher Intervention):

- (1) **Framing the Discussion:** Focused teacher attention on specific learning outcomes.
- (2) **Prompting Reflection:** Elicited observations on task design and language use.
- (3) **Question Structure:** Closed format limited exploratory dialogue.

**Outcome:** Teachers acknowledged the learning connection but deeper insight was missed due to question structure. This highlights the importance of how researcher structures questions to encourage richer discussions and insights.

#### *Interaction 6. Role of Story in Design Assessment*

**Context:** Researcher's question during post-lesson discussion in class 4 led teachers to reflect on the impact of using a story in design activities and whether it was essential for structuring pupils' thinking.

##### **Interaction Transcript 6:**

- (1) Researcher: Do you think the connection of the story helped them in design, or could you do this design without even a story?
- (2) Ms Jane: Yeah, you could do the design without the story because I don't think they really remembered it that well. But . . . That's good for that age, because otherwise they could go anywhere. But that's me(a teacher), wanting structure.
- (3) Ms Rose: Yeah, maybe. I don't know. Well, what do you think (pointing to researcher)?
- (4) Researcher: For me, it's the same, it gives them a purpose, to make it more empathetic, as that was the learning objective for you.
- (5) Ms Rose: But then it helps in your assessment too and the children's assessment of their structures.
- (6) Ms Jane: It's clearer-does it fit the function?
- (7) Ms Rose: Yeah, it gives a kind of stimulus.

Ms Jane highlighted the potential to design without the story, but also noted how the story helped bring focus to the task, preventing pupils' ideas from wandering. Researcher's intervention came when Ms Rose asked for researcher's opinion. Researcher provided a short answer summarizing Ms Jane's point and encouraged teachers to think about the purpose behind instructional choices and allowed them to weigh both practical ("it gives them purpose") and pedagogical consideration (addressing learning objective). Ms Rose built on this by connecting the story to pupil assessment, noting that it helped clarify whether the design met the functional goals (e.g. solving the problem of the story).

Mechanism (researcher Intervention):

- (1) **Challenging Assumptions:** Encouraging critical review of story use.
- (2) **Summarizing and Focusing:** Reinforcing story's alignment with objectives.
- (3) **Connecting to Pedagogy:** Framing stories as stimuli and assessment tools.

**Outcome:** Teachers saw added value in stories for guiding and assessing designs. While the discussion clarified the story’s role in providing structure and purpose, researcher’s intervention could have gone further by asking an open-ended follow-up question (e.g. “Can you tell us more about how the story can be used for assessment?”). This could have deepened the discussion, leading to a richer understanding of how stories can be integrated as assessment tools in design-based learning for these teachers.

*Interaction 7. Highlighting Gestures and Visualization*

**Context:** Post-lesson discussion in Class 6 during second LS cycle.

**Interaction Transcript 7:**

- (1) Researcher: You were using gestures very frequently this time . . . Do you think the same? Is there any difference in their sketching this time compared to last time?
- (2) Ms Grainne: I think the actual structures were more imaginative than the sketches that some of them made.
- (3) Ms Katherine: The sketches were very much about an aeroplane or boat. These sketches were basically similar (to last time), but when they actually created them, the designs were a lot more detailed.

The researcher’s appreciation of gestures and visualization led to teacher reflection. Teachers noted greater imagination in built structures compared to sketches. However, two questions were asked at once (line 1), limiting focused reflection. Additionally, researcher could have prompted further discussion by asking how gestures impacted the case pupils specifically or in what ways the built structures were better, which would have encouraged teachers to think critically about supporting the sketching process next time.

Mechanism (Researcher Intervention):

- (1) **Encouraging Reflection:** Acknowledging teacher strategies.
- (2) **Prompting Comparison:** Inviting links between sketching and designing.
- (3) **Highlighting Practice:** Subtly reinforcing spatial strategies.

**Outcome:** Teachers noted improvements in construction but not in sketching (Image II, Left). A missed opportunity for discussing sketching support strategies.

Summary of Findings addressing our sub-research questions are in Table 2. In next section we discuss these finding in details.

**6. Discussion**

The role of the researcher in Lesson Study has traditionally encompassed that of a pedagogical advisor and facilitator (Clivaz and Clerc-Georgy, 2021). However, in contexts where both LS and the target content (such as spatial thinking) are unfamiliar, our findings suggests that the researcher must not only guide the LS process but also co-design the intervention and provide timely pedagogical impulses based on context. These expanded responsibilities reflect the evolving nature of LS in non-Japanese contexts, where local conditions and teacher unfamiliarity require a responsive, context-sensitive approach (Hourigan and Leavy, 2024; Lewis, 2020). As such, the researcher’s role becomes both strategic and developmental, aiming to balance guidance with the gradual transfer of ownership to the teacher team (Lewis, 2020).

*6.1 Researcher strategies supporting teacher talk on spatial thinking (sub-question 1)*

Key strategies used by the researcher to initiate and maintain productive dialogue included reassurance, the reframing of teacher concerns into inquiry opportunities, and structured

**Table 2.** Summary of findings for sub-research questions 1 & 2

| Sub-research Question and main finding                                                                                             | Relevant interactions | Description of researcher interaction                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| <i>Addressing RQ1: Researcher strategies that initiated or sustained productive talk about case pupils' spatial reasoning</i>      |                       |                                                                                                                                     |
| Strategic reassurance, sharing expertise with classroom examples, and offering practical solutions                                 | 1–3, 5                | Acknowledged teacher concerns; provided concrete examples to reframe challenges as learning opportunities                           |
| Promotion of growth mindset and reassessment of pupils' potential                                                                  | 2, 3                  | Highlighted children's creative abilities; challenged teacher assumptions through classroom examples                                |
| Dialogic questioning to support reflective practice and prompting comparison                                                       | 5–7                   | Used strategic questions to prompt analysis of language use, lesson framing, and gesture in practice                                |
| Facilitation via summarizing, focusing, challenging assumptions, and connecting to pedagogy                                        | 2, 6                  | Fostered open, co-constructive exchanges for joint reflection and deeper inquiry into pupil thinking                                |
| <i>Addressing RQ2: Researcher facilitation supporting or hindering teacher learning across professional development dimensions</i> |                       |                                                                                                                                     |
| Increased teacher satisfaction and building trust                                                                                  | 1, 4                  | Positive pupil engagement and creative responses fostered trust and satisfaction between researcher and teachers                    |
| Knowledge enhancement through multimodal pedagogical strategies                                                                    | 2, 7                  | Confirmation and elaboration on teacher's intuitive practices (gesture, visual scaffolding) and introducing sketching before design |
| Shifts in teaching practice and flexible lesson planning                                                                           | 1, 5–7                | Teachers adapted plans after workshops, incorporating more intentional spatial reasoning strategies after classroom observation     |

questioning. For example, in [Interactions 1–3](#), the researcher encouraged teachers to try sketching activities before construction. This not only reassured them of the activity's value but also helped them pay closer attention to the use of spatial language during lessons. This aligns with previous findings that observational drawing supports young children's pattern recognition ([Kelley and Sung, 2017](#)) and conceptual learning ([Dotger and Walsh, 2015](#)). Moreover, the researcher missed the opportunity to use structured questioning (e.g. [Interaction 5–7](#)) to help teachers explore single issues in depth before shifting focus. This deliberate pacing could enable teachers to link their reflections to case-pupil observations, a method that strengthened reflective authenticity ([Lewis, 2016](#)) and facilitates the recognition of spatial thinking in practice. Additionally, the researcher's framing of reflection questions and summarizing techniques proved critical. [Mynott \(2018\)](#) identifies different types of facilitator summaries, for example, those that validate or provoke dissonance. To scaffold deeper reflection, visual artefacts such as observation matrices and concept maps could be used. This proposal aligns with emerging research on incorporating "more-than-human" reflective tools, such as concept mapping, to support teachers' collective meaning-making and deepen their engagement with pupil thinking ([Oates and Mynott, 2025](#)).

## 6.2 Researcher's role in supporting teacher learning across professional development dimensions (sub-question 2)

**6.2.1 Satisfaction.** Teachers reported a sense of accomplishment and motivation when pedagogical strategies like sketching were validated by pupil engagement in the classroom (interaction 1–3). This satisfaction grew from the researcher's reassurance and recognition of teacher efforts ([Mynott, 2018](#)), an essential factor in early-stage LS settings.

6.2.2 *Knowledge enhancement*. This included linking teacher observations to spatial concepts and facilitating teacher use of spatial language and gesture ([Interaction 5-7](#)) during post-lesson reflections with an idea of formative assessment as suggested by [van Halem et al. \(2016\)](#).

6.2.3 *Teaching practice*. Teachers began to internalize new practices, such as encouraging sketching or focusing more attentively on pupils' spatial reasoning in their planning and delivery. The researcher's facilitation helped shift teacher mindsets from a broad focus on "what worked" to a finer analysis of why certain instructional moments prompted spatial engagement; a distinction that [Lewis \(2020\)](#) argues is essential in meaningful LS.

The researcher's role required responsive interventions to guide teacher talk toward learning goals. Future facilitation may benefit from structured questioning by asking one open-ended question at a time to support deeper engagement ([Interaction 5](#) and [7](#)). Connecting teacher observations to intended learning outcomes ([interaction 6, 7](#)) can also clarify pedagogical aims. In addition, using tools like Bansho, as described by [Tan \(2021\)](#), during post-lesson discussions may help make pupil thinking more visible.

## 7. Study limitations

The first author's dual role as both researcher and facilitator may have introduced interpretive bias, though peer validation and collaborative analysis were used to mitigate this. Ethical constraints prevented video recording, limiting analysis of non-verbal interactions and researcher-teacher dynamics. While two LS cycles were completed, a longer study could better capture researcher's changing role and sustained impacts on teacher practice and beliefs.

## 8. Conclusion

This study highlights the evolving, context-sensitive role of the researcher in facilitating Lesson Study (LS), especially when early-childhood educators engage with it for the first time in a novel pedagogical area. Beyond procedural coordination, the researcher provided reassurance, strategic questioning, and framing that fostered shifts in teacher confidence and instructional practice. While core LS mechanisms such as iterative planning, examining practices, collaborative reflection, and a focus on case pupils' thinking remained central ([Dudley and Vrikki, 2019](#); [Goei et al., 2021](#); [Kager et al., 2023](#); [Lewis, 2020](#)), this study underscores the importance of adaptive facilitation in early implementation to spark teacher inquiry and change.

Following [Lewis \(2016\)](#), who connects LS facilitation to an "emergent curriculum", this study highlights the researcher's adaptive role in curating practice-based experiences. Beyond supporting LS fidelity, the findings contribute to pedagogical innovation. The observable nature of spatial thinking makes it a strong entry point for introducing LS to EC educators. We recommend integrating LS into teacher training to help educators shift from solely emergent approaches to more systematic strategies for observing, interpreting, and documenting children's development. Since EC educators design learning environments rather than deliver formal lessons, LS could support intentional reflection on children's spatial thinking using observation and post-lesson discussion protocols.

Future research should explore how sharing knowledge beyond individual Lesson Study (LS) groups supports wider educational communities, including teachers, school leaders, and training providers, in sustaining LS in new content area. Embedding facilitation within schools and teacher education can strengthen this process. While toolkit for teachers ([Gifford et al., 2022](#)) offers guidance for developing spatial reasoning, they require local adaptation to be effective ([Farran et al., 2024](#)). This study illustrates the value of such local adaptation. As experiences accumulate, facilitation and design approaches can evolve to support the collaborative development of practice-based knowledge in new content areas more effectively.

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## Appendix A

### Noticing spatial moments in classroom using Lesson Study

- (1) Before the first research lesson, use your professional judgement to identify three pupils—Mastering, Developing, and Beginning in spatial thinking and design tasks.
- (2) The observation sheet focuses on pupil learning, not teaching.
- (3) Observe the four tools of spatial thinking (language, gestures, story-based design, manipulatives with “think then do”) and note their effects at different lesson stages.

Teacher: . . . . . Observer: . . . . .

**Table A1.**

Learning goal: . . . . .

Materials: . . . . .

Case pupil information panel

*Case pupil A: Mastering*  
*Success criterion for this focus*  
*By the end of the lesson . . .*  
*Additional notes*

*Case pupil B: Developing*  
*Success criterion for this focus*  
*By the end of the lesson . . .*  
*Additional notes*

*Case pupil C: Beginning*  
*Success criterion for this focus*  
*By the end of the lesson . . .*  
*Additional notes*

Case pupil\* (make three copies of this page: one each for pupil A, pupil B, and pupil C)

Patterns/  
issues

Stage of lesson sequence

How you predict  
case pupil will  
respond

How they are  
observed to  
respond

Design process

What progress have they made and how do you  
know?

Note down the key moments and development in  
their spatial thinking (use of spatial language and  
gesture)

## Appendix B

### Questions to facilitate Post-Research Lesson Discussions

These questions were not used in sequence but used flexibly, to explore teachers’ planning, strategies, and ability to reflect and adapt.

#### Lesson Objectives and Techniques:

- (1) What is the main objective of this research lesson?
- (2) How do you choose materials for your lessons, and what makes these materials spatially relevant for the activity?

**Starting with observation on 3 case pupils (using observer's notes following [Appendix A](#))****Lesson Sequence and Adaptation:**

- (1) Can you describe the stages of your lesson sequence, starting with how you introduced the design task?
- (2) Reflecting on the lesson, are there any changes or improvements you would make in the next iteration?

**Storytelling and Design Task:**

- (1) How was your experience with storytelling in this lesson, and do you believe it added value to the design task?
- (2) How challenging was it for you to come up with the design task? Could you share any specific challenges you encountered and how you overcame them?

**Observation and Challenges:**

- (1) What challenges did you face while observing your peers and students during the activity?
- (2) How did you motivated your case pupils, and what aspects of the lesson do you think they found most interesting?

**Feedback and Assessment:**

- (1) In what ways did you incorporate assessment and feedback to support children's spatial thinking during the design activity?

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