



Early Childhood Teachers' Reported Strategies for Integrating Mathematics and Science Through Play

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Abstract:

Background: Play-based learning can connect early mathematics and science through children's exploration. However, limited evidence explains how teachers establish conceptual relationships between the two domains during play.

Objective: This study examined how early childhood educators plan, facilitate, and assess integrated mathematics and science learning through play, focusing on relational integration.

Methods: A qualitative descriptive study involved 10 early childhood educators. Data were collected through asynchronous written semi-structured interviews using a 37-question instrument. Data were analyzed using deductive-inductive thematic analysis through coding, category development, theme review, and cross-participant comparison.

Results: Seven themes emerged: goal-oriented planning, relational integration, questioning and prediction, scaffolding and child agency, material and environmental exploration, formative assessment, and professional experience and training. Teachers integrated mathematics into science-based play through counting, measuring, comparing, and classifying, supported by open-ended questioning and adaptive scaffolding.

Conclusion: Relational integration involves using mathematical actions such as counting, measuring, comparing, and classifying to support science exploration. The findings reflect teachers' reported practices and do not establish effects on children's learning outcomes.

Keywords: Early childhood education, Guided play, Mathematics and Science, Relational integration, Teacher self-report

1. INTRODUCTION

The introduction of mathematics and science to early childhood education is an important part of building the foundations of thinking, reasoning, curiosity, and problem-solving skills (Svane et al., 2023). Early mathematics includes not only the ability to recognize number symbols and count, but also experience with numbers, sizes, shapes, patterns, spaces, classifications, measurements, and comparisons (Stramel & null, 2021).

Similarly, the introduction of science is not primarily intended to make children memorize scientific terms, but rather to give them the opportunity to observe, question, predict, try, compare, and recognize changes that occur in the environment (Lestiwati et al., 2023; Yin et al., 2026). Emphasize that early math learning needs to be aligned with the child's level of thought development (Weber et al., 2020), while (Srianita, 2022) point out the importance of learning experiences that actively engage children. Also places play and educator involvement as an integral part of a quality learning experience in the early stages (Ndlovu & Mncube, 2021). Within this framework, the quality of learning is determined not only by the material introduced, but also by how the teacher relates the learning objectives to the child's concrete experience (Adbo & Carulla, 2020; Nasution et al., 2024). Therefore, the teacher's strategy is an important factor in determining whether play activities stop as fun experiences or develop into meaningful conceptual experiences.

One of the relevant perspectives for understanding early mathematics learning is learning trajectories (Brady, 2023; Calder & Murphy, 2023). This framework connects learning objectives, the development of children's ways of thinking, and activities that can be

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used to gradually expand understanding (Janßen et al., 2020; Rahmawati et al., 2026). This principle requires teachers to read the child's actual abilities and adjust the support and level of challenge (Mumu et al., 2025; Ponte et al., 2023). Show that digital games based on learning trajectories can support mathematics learning (Hurst & Linsell, 2020), while (Lafay et al., 2022) affirm the importance of scaffolding, personalization, leveling, and feedback in mathematics applications. The fundamental similarity between digital learning and in-person learning is that media does not work automatically (Susanti et al., 2025). Teachers or learning systems need to direct experiences to match the child's developmental level (Godino et al., 2023). The study of (Keldgord & Ching, 2022) also shows that the use of physical manipulatives does not always produce uniform effects, so the quality of implementation and pedagogical goals need to be considered. Thus, concrete objects, games, and technology are more appropriately understood as pedagogical mediums than as effective methods in themselves (Lehtonen, 2021).

Play activities provide a relevant context to introduce math and science because they allow children to interact directly with objects and situations (Ahmad et al., 2024). However, play-based learning is not a one-size-fits-all approach (Björklund et al., 2020; Højgaard et al., 2024). Games can be free games, guided games, structured games, games with rules, constructive games, manipulative games, and technology-based activities (Chambrier et al., 2020). Guided play is important because it places activities at the intersection between the goals of the teacher and the child's agency (Karlsson et al., 2025; Reikerås, 2020). Describe guided play as an approach in which adults have specific learning goals, but the child retains meaningful control over his or her exploration process (Chatzaki et al., 2024; Dunekacke et al., 2024). Also place this kind of approach as an alternative to bringing together curricular goals with active children's learning methods (Hundeland et al., 2020). That play alone is not always enough to produce targeted mathematical development (Flatén, 2022; Meaney et al., 2025). Thus, teachers still have an important function in setting goals, asking questions, providing media, providing hints, and assessing children's responses without taking over the playing experience (Kurniasih et al., 2020).

In STEM and STEAM education, these roles are increasingly complex because teachers need to see interdisciplinary relationships (Bondía et al., 2023; Pérez-Lisboa & Mejías, 2026). Show a growing interest in STEM, STEAM, and makerspace in early childhood education (Oli et al., 2024), while (Skalstad et al., 2025) show that STEAM studies are moving towards more integrative and experiential experiences. Identified the development of the use of STEAM in preschool education (Núñez & Manzano, 2025), while (Rahmadini & Sari, 2025) showed that integration can be developed through technology-based and robotics-based programs.

Nonetheless, integration doesn't have to rely on high technology. That nature-based outdoor environments have the potential to support the formation of the STEAM concept (Wahyuni et al., 2025). Water, soil, leaves, stones, plants, light, shadows, and everyday objects can be materials for observing, calculating, measuring, classifying, or comparing. This potential still depends on the teacher's ability to recognize the conceptual relationships that can be developed from the child's interaction with the environment (Jendera & Peterianus, 2026).

Teacher competence is an important issue in implementation (Roehrig et al., 2021). That STEM education in the early days requires a change in pedagogical strategies (Cascella, 2022), while (Murzabaev et al., 2022) shows the importance of teachers' belief in STEAM. Highlight teacher confidence in early STEM education, while (Beier & Blossfeld, 2023) identify issues of teacher knowledge, curriculum, inquiry, technology, and the environment as part of implementation challenges. Teachers are therefore not enough to just know that play-based learning or STEM is important; They need to be able to translate those ideas into pedagogical decisions, such as choosing the right questions, determining when help is needed, providing materials, and adjusting the level of challenge (Kalaitzi, 2024; Yusuf et al., 2026). Professional development is important to improve these abilities (Rutkienė & Narusaitiene, 2024). In the context of science education, (Dündar, 2025) also show the relevance of teacher professional development to the quality of children's learning experiences. Thus, the quality of the integration of mathematics and science can be understood as the result of the interaction between concept knowledge, pedagogical skills, environmental conditions, and reading ability in children's development (Widayati, 2026).

The integration of mathematics and science has a strong foundation in children's daily experiences. When children plant seeds, they can observe growth while counting the number of seeds, comparing plant heights, or measuring changes (Alashwal & Barham, 2025). When children play with water, they can observe the properties of liquid objects while comparing the many-little, full-empty, or capacity of the container. When children play with blocks, the concepts of number, shape, length, and height can meet with the concepts of balance and structure (Iqbal et al., 2026). This kind of pattern is more substantive than simply placing the computational and experimental activities at the same time without a conceptual relationship. STEM education provides opportunities to build those relationships because children can use more than one way of thinking when solving problems (Rahmadini & Sari, 2025). Therefore, the quality of integration needs to be analyzed based on the way teachers connect concepts, not just on the number of disciplines listed in the planning.

The literature on informal learning shows that the experience of mathematics and science can also be built through everyday space. (Callanan et al., 2020) show that intentionally designed play environments can give rise to more STEM interactions and language. (Cronin-Golomb & Bauer, 2022) through the concept of Learning Landscapes places public spaces as potential locations for learning through play. (Tamis-LeMonda, 2025) show that community-based math-science programs can support caregiver involvement, while (Neilson et al., 2026) emphasize the relationship between family math activities and child learning. The literature shows that children's learning resources are not limited to formal media. However, a rich environment does not automatically result in understanding; Adult questions, experiential design, and support during exploration remain an important part of turning everyday objects and events into a source of conceptual learning.

The research on play-based learning, early STEM/STEAM, manipulatives, environmental exploration, and teacher professional development is expanding, but little is known about the micro-pedagogical strategies instructors use to combine science and arithmetic in a single play episode. Previous research frequently identifies integrated activities or program types, but it pays less attention to the ways in which teachers create questions, solicit predictions, choose materials, modify prompts, scaffold participation, and evaluate evolving understanding as a cohesive system. This gap is significant because conceptual integration is not always produced by the coexistence of science and mathematics. It is challenging to explain how an apparently integrated activity goes beyond just displaying two curricular labels side by side in the absence of evidence regarding these spontaneous pedagogical decisions.

The current work employs relational integration as an analytical paradigm to close this gap. A reported instructional arrangement known as "relational integration" involves the use of mathematical operations, such as counting, measuring, comparing, classifying, ordering, or expressing, in the investigation of a scientific fact. It is not the same as STEM/STEAM integration or generic mathematics-science integration since it outlines the conceptual role of one domain in supporting inquiry in another. It is also not the same as merely carrying out science and math activities in the same play space. Thus, the study poses the following question: What methods do early childhood educators report employing to organize, support, and evaluate play-based, relationally integrated math and science learning? Additionally, it takes into account how different training backgrounds and professional experiences affect how these methods are articulated, both descriptively and inferentially.

2. MATERIAL AND METHOD

Research Design, Context, and Participants

In order to investigate educators' descriptions of how they comprehended, organized, and supported the

integration of science and mathematics through play, this study used a qualitative descriptive design. Each educator's written story regarding pedagogical practices served as the analytical unit. Accordingly, rather than being behavior confirmed by classroom observation, each finding is regarded as self-reported practice or comprehension.

Ten informants who were employed in early childhood education or engaged in supervised practice took part. They represented multiple early childhood education institutions rather than a single field site and ranged in age from 24 to 51. Their stated class sizes varied from nine to thirty-eight students, and their professional experience spanned from internship to twenty years. In order to investigate accounts from interns, less experienced educators, and more experienced educators, the participant set was purposefully varied. In order to be eligible, a person had to be actively involved in early childhood education and be prepared to fill out the written form; those who were not in that setting or who did not submit answers that could be used were excluded. Recruitment went on until ten complete responses with a range of professional backgrounds were provided. This sample was not meant to support statistical generalization, but it was deemed adequate for the constrained descriptive goal of discovering recurrent approach patterns.

G02, G04, G07, and G09 were classified as novice or intern participants for a limited comparative reading, while G01, G03, G05, G06, G08, and G10 were classified as more experienced individuals. Only contextual interpretation was assisted by the grouping; statistical testing was not conducted using it. In the analytical file and in reporting, codes G01–G10 took the role of names and substitution IDs.

Data Collection Procedure

Data were obtained asynchronously using a textual, semi-structured interview tool on August 13–14, 2026. The asynchronous structure was designed to allow participants from multiple institutions to engage without the requirement for a single in-person session, to offer all participants the same breadth of questions, and to allow time for reflection. The trade-off was in the depth of interaction, because the researchers couldn't see nonverbal cues, generate spontaneous inquiries or clarify responses in real time. Thus, the data should be regarded as written descriptions and not as transcripts of oral interviews or practice observations.

Participation was purely voluntary. When reporting, the informants were informed of the purpose of the study, the use of their answers, and the protection of their identity. Returning the written form indicated formal consent to participate. Names and other identifying information of institutions were not included in the study. The analysis and publishing were based only on coded data. These protocols fostered lower disclosure risk, secrecy and informed participation.

Research Instrument and Written Follow-up Questions

The instrument comprised 37 main questions covering professional characteristics, understandings of mathematics and science, planning, play forms, concept integration, questions and prompts, prediction, scaffolding, media, experiments, environmental exploration, assessment, constraints, enabling factors, and reflection. Some items featured pre-written follow-up prompts asking for examples, justifications, types of support, or planned follow-up. These prompts were normal parts of the device and are not presented as spontaneous probes. The seven synthesis questions at the conclusion returned to the main domains and allowed for comparison with the detailed responses provided earlier by the subjects. Instrument domains and example questions are provided in Appendix A.

Data Analysis and Trustworthiness

Analysis used both deductive and inductive thematic approaches. First, all the comments were reviewed several times and divided into meaning units. Second, initial descriptive codes were assigned based on both the instrument domains (e.g., planning, questioning, scaffolding, materials, and assessment) and concepts that emerged from the participants' phrasing (e.g., mathematics as a tool for arranging science observations). Third, similar codes were classified into categories. Fourth, comparisons across participants led to the development of potential themes. Fifth, the themes were examined by reviewing the coded excerpts and the entire set of responses to ensure internal coherence and distinctiveness. The process yielded seven themes: goal-oriented planning; relational integration; questioning and prediction; scaffolding and child agency; materials and environmental exploration; formative assessment; and professional experience and training.

The principal author performed the main coding and maintained an audit record of connections between meaning units, codes, categories, and themes. Alternative interpretations were considered by repeatedly comparing with the original responses and discussion between authors, and assertions were narrowed when data did not support a stronger interpretation. Cross-participant comparison, deliberate

use of verbatim extracts, and comparison of the seven synthesis responses with previous thorough answers enhanced credibility. The coding sequence was recorded, and the analytical definitions were applied consistently, which supported the reliability. Confirmability was increased through separating participant reports from researcher interpretation and through keeping explicit negative caveats, such as the non-linear link between experience and response complexity. Transferability was encouraged through a description of the age, experience, class size, education, and training backgrounds of participants. Counts were used simply to describe the sample or category mentions, not to make inferential claims.

Scope and Methodological Boundaries

The study did not entail live observation of classrooms, recordings of teacher-child interaction, review of institutional documents, or direct assessment of children's results. Claims concerning questioning, structuring, experiments, evaluation, and children's replies Participants' views and written accounts thus limit claims regarding questioning, structuring, experiments, evaluation, and children's replies. views and written accounts of participants. Differences in written expression could also have influenced response length and detail; response length was not viewed as a direct measure of pedagogical competence.

3. RESULTS AND DISCUSSION

3.1 Result

The 10 participants had heterogeneous work backgrounds. They were aged between 24 and 51 years; 9 were women and 1 was a man. Reported class sizes ranged from 9 to 38 children. Three had early mathematics training, four had science training, three had STEM/STEAM instruction, and eight had play-based learning training. Table 1 outlines the characteristics of the participants. This variety provides a framework for the interpretation of the themes. It does not suggest that the participants were representative of the larger population of early childhood educators.

Table 1. Participant characteristics

Code	Age	Edu.	Experience	Child age	Class n
G01	43	SMA	20 years	5–6	13
G02	33	SMA	3 years	5–6	35
G03	37	SMA	20 years	5–6	17
G04	24	SMA	Internship (Early Childhood Islamic Education student)	4–5	28
G05	51	SMA	11 years	5–6	10
G06	43	SMA	18 years	5–6	22
G07	24	S1	2 years	4–6	15
G08	30	S2	8 years	4–5	20

G09	30	SMA	Internship (Early Childhood Islamic Education student)	4–6	9
G10	38	S2	14 years	5–6	38

Theme 1: Planning with an Eye toward Integrated Play
Participants noted the importance of starting with learning goals, themes, children's developmental levels and interests, available media, and safety considerations. The activity context was then selected to allow mathematical and scientific concepts to originate from a shared experience. The reported scenarios included planting, garden-ing, water play, floating-and-sinking activities, blocks, classification of natural materials, color mixing, light and shadow, cooking, outdoor exploration, and limited usage of digital media. G06 mentioned that goals were stated beforehand, but the activity was flexible depending on the children's engagement. *"Children can know about the concept of science by planting seeds... Meanwhile, children can also know about the mathematical concept by counting the number of seeds, comparing many little ones, and measuring the plant growth."* (G01).

Theme 2: Integration of Mathematics and Science in Relation

Table 2. Reported Play contexts and Relational Integration

Activity	Mathematics	Science	Reported strategy
Planting	Count, measure, compare	Growth, needs	Prediction, observation
Float-sink	Classify, count, compare	Material properties	Open questions, test
Water play	Volume, more-less	Liquid properties	Prompt, exploration
Blocks	Shape, size, number	Balance, structure	Scaffolding, problem solving
Nature materials	Classify, pattern	Observe properties	Outdoor exploration

Theme 3 - Questioning and Predicting

Participants spoke of questions that turned attention but did not provide the instant answer, e.g., "What happened?", "Why might it be like that?", "What if ...?", "Which one is more?", and "What do you think will happen?" Experiments often involved predictions about water, floating and sinking, plant development, color mixing, ice, light and shadow, and magnets. Questions from participants pushed children from noticing an occurrence to anticipating, comparing, and understanding outcomes. These are reported question forms; their frequency and quality in classroom engagement were not observed.

Theme 4: Child Agency and Scaffolding

Participants reported clarifying a question, diverting attention to an object, providing limited alternatives, modeling one example, or inviting the kid to examine again when children did not react. Several educators talked about scaling back the help when students were able to manage on their own. This approach positioned

The most frequently identified mathematical content was counting, number, size, shape, length, height, volume, pattern, categorization, location, space, and comparison. Their science accounts included observation, prediction, experimentation, change, cause and effect, plants, water, light, magnetism, and material properties. Examples of relational integration include mathematical operations that organized, represented, or expanded scientific research, such as counting floating and sinking objects, measuring plant height over time, comparing container capacities, or classifying materials according to observed attributes. Table 2 lists these reported relationships.

"The child groups floating and sinking objects, counts the number, and compares which groups are in greater number." (G06)

"The two ideas are combined into a single meaningful activity, where mathematics becomes a tool to understand science." (G07).

scaffolding as contingent support rather than a fixed script, maintaining child agency in guided play.

"Children who can manage are provided some guidance; children who are still struggling receive more help ... My support is gradually reduced." (G01).

Theme 5: Exploration of Material and Environment

The most common materials in the reports were concrete and environmental: water, cups, bottles, seeds, leaves, stones, sand, soil, cardboard, blocks, repurposed materials, rulers, and simple scales. The pedagogical value was not attributed to an inherent quality of the objects themselves but to the acts that the children performed with the objects: observing, predicting, sorting, counting, measuring, testing, and comparing. Digital media appears to be a supporting resource, not the primary context for integration

Theme 6 Formative Evaluation

Participants reported using children's responses, behavior during play, repeated performance of an

activity, products, anecdotal notes, photo-graphs, films, and portfolios to assess them. Some accounts connected evaluation to later planning by modifying task complexity or amount of assistance. The study did not examine assessment records; therefore, the finding reflects how participants understood and reported formative assessment rather than the quality of its implementation.

Theme 7: Professional Experience and Training

Some experienced participants, especially G01, G03, G05, G06, and G10, gave nuanced narratives that linked aims, prediction, staged help, and assessment. Some rookie or intern participants were more likely to describe demonstrations, media, or concrete examples of action. The process was not linear: G07, with about two years of experience, plus exposure to science, STEM/STEAM, and play-based learning training, described extensive accounts of integration and scaffolding. Participants also cited restrictions of time, big groups, restricted media and space, safety, variety in children's skills, and teacher competence and described collegial, leadership, parental, environmental, and training support as enabling factors. The complexity of the reported tactics Experience alone did not explain the complexity of the reported tactics. by experience alone.

3.2 Discussion

The results support earlier work on directed play by detailing the micro-pedagogical moves via which participants described linking curricular goals with children's agency. Previous work highlights goal-directed, yet child-directed activity and the value of adult assistance for play-based learning. Here are the operational sequence steps added to the present accounts: define an integrative aim; choose a phenomenon and materials; invite prediction; direct observation through questions; alter scaffolding; and utilize children's replies to influence the next phase. This sequence remains a teacher-reported model, but it does specify what "integration through play" might look like in terms of pedagogical decision-making.

The main conceptual contribution is relational integration. Broad STEM/STEAM frameworks articulate the benefits of multidisciplinary and experiential learning, but do not often distinguish conceptual connection from curricular co-location. In this study, the integration was relational in that a mathematical action served a purpose in scientific inquiry. For example, counting reflected experimental outcomes, measurement recorded change, categorization arranged observed properties, and comparison aided interpretation. Thus, this formulation limits the notion of

integration and provides a criterion to evaluate the design of activity. For example, a planting operation is not relationally integrated just because both counting and plant growth are discussed. Counting or measuring is considered relational when it is used to record and analyze growth.

The participants reported using open inquiries, prediction, and incremental guidance, which is consistent with the literature on guided play and inquiry-oriented perspectives. It also broadens them by demonstrating how these tactics can span across domains, rather than supporting just one content area. Prediction geared to science began with questions such as, "What do you think will happen?" "Which group has more?" led to a mathematical comparison that structured the conclusion. This distinction matters because the same query might either adorn an activity or promote conceptual reasoning depending on its link to the phenomenon being investigated. No classroom interaction was recorded; therefore, the research cannot determine if participants consistently enacted this distinction.

The use of natural, repurposed, and everyday materials aligns with studies on nature-based learning environments and purposely planned play spaces. The present study qualifies that agreement: materials were meaningful in the accounts of participants only when accompanied by deliberate behaviors such as sorting, measuring, predicting, and testing. This finding is consistent warning that manipulatives do not necessarily result in learning. Theoretically, this finding implies that relational integration is in the structure of mediated activity, rather than in the novelty or technological sophistication of the material.

Professional experience indicated a qualified rather than consistent link with strategy articulation. Experienced educators described more integrated planning, scaffolding, and evaluation cycles, consistent with literature citing teacher preparedness and professional development. G07's rich description suggests, however, that relevant training can somewhat compensate for shorter experience. Such a departure from a simplistic experience-expertise assumption implies that future explanatory models should consider interactions between instruction duration, content knowledge, quality of training, opportunities for practice in integration, and institutional support.

Finally, participants' stories connected formative assessment to changes in task difficulty and support,

reflecting the logic of learning trajectories in which evidence about children's current thinking informs subsequent experience (Clements et al., 2023). But the study did not look at assessment artifacts or children's performance. The contribution is a documented instructional approach, not evidence that the tactics have enhanced mathematical or scientific progress. Testing relationally integrated episodes in observational and mixed-method research will determine whether they occur as stated and whether their quality predicts children's development.

3.2.1 Implication

The findings have theoretical, pedagogical, professional-development, and institutional implications. Theoretically, relational integration offers a criterion for distinguishing substantive mathematics/science connections from the simple co-location of two subject areas. Pedagogically, integrated play should align learning objectives, scientific phenomena, mathematical actions, teacher questions, scaffolding, and formative assessment within one coherent activity. For professional development, educators need opportunities to practice designing conceptual links and adapting support while preserving children's agency. At the institutional level, school leaders and teacher teams can support collaborative planning, appropriate materials, manageable learning conditions, and review of integrated teaching documents. These implications concern the application of the reported framework; they should not be interpreted as evidence of effectiveness for children's outcomes.

The second implication is the need to translate relational integration into learning planning documents, including Semester Learning Plans or equivalent semester planning documents, Teaching Modules, and Daily Learning Implementation Plans (RPPH). Documents should not simply write down math and science indicators as two separate lists. Goals can be formulated integratively, for example: children are able to observe changes in plant growth and use counting and measuring activities to compare plant development over time. This kind of formulation makes the math-science relationship visible from the administrative stage and gives a clearer direction to activities, questions, scaffolding, and assessments.

The third implication is the need to include a concept integration matrix into the Teaching Module or RPPH. The matrix can contain the context of play, science concepts/processes, mathematical actions used, teacher strategies, and evidence of child development. The structure helps teachers avoid superficial integration because each activity must demonstrate a real connection between the science process and the use of mathematics. Open-ended questions and scaffolding strategies also need to be written as an explicit part of planning, rather than just being left to improvisation as learning progresses.

An operational example of a relational integration matrix that can be incorporated into the Teaching Module/RPPH is shown in Table 3.

Table 3. Example of a Relational Integration Matrix for a Teaching Module/RPPH

Play context	Science	Mathematics	Teacher strategy	Assessment evidence
Float-sink	Observe, predict, test	Classify, count, compare	Open question, prompt, scaffold	Child groups objects, counts results, explains comparison

The fourth implication is the need to integrate formative assessments into planning documents. Observational indicators can be directed at how children use counts to compare experimental results, use measurements to observe changes, classify objects based on observations, or explain simple relationships. In this way, the assessment does not rigidly separate math and science achievement, but assesses how both types of knowledge are used in a single play experience.

The fifth implication is the need for institutional support. Principals and teacher teams can develop a Teaching Module/RPPH format that provides a special space for integrative purposes, cross-concept relationships, ignition questions, scaffolding strategies, and assessments. Collaborative planning can be used to review whether an activity actually demonstrates relational integration or simply puts two areas in one activity. Operationally, this study recommends a flow:

the context of play → integrative objectives → science concepts → mathematical actions → children's activities → teacher questions → scaffolding → formative assessments.

3.2.2 Research Contribution

Within the limits of self-report data, the research yielded three contributions. First, the research identifies integration as a series of pedagogical decisions that include objectives, activities, media, questions, predictions, help, exploration, and assessment. Second, the research proposes the concept of relational integration, which is a condition when mathematics is used functionally to support the understanding of scientific phenomena. Third, a comparison of professional experience shows that the length of teaching can be related to the depth of strategy articulation, but not singularly determinant; Training exposure and

professional background also need to be considered. This contribution directs attention from just a type of play activity to the quality of conceptual relationships and pedagogical mediation that teachers report.

3.2.3 Limitation

Collection uses semi-structured written interviews so that it does not allow for spontaneous probing, nonverbal expression readings, or real-time clarification. Second, consistency checks were conducted through detailed response comparisons and seven synthesis questions, but did not include oral member checking after filling. Third, all practice data is self-report; The study did not have classroom observations to verify the pattern, intensity, and quality of the strategy. Fourth, children's responses come from teachers' perceptions and are not supported by measurements of mathematical or science development. Fifth, the professional experience of informants is very heterogeneous and the number of informants is limited, so the comparison of experiences is descriptive. Sixth, the ability to express ideas in writing can affect the length and depth of answers, so short responses cannot automatically be interpreted as inferior pedagogical competence.

3.2.4 Suggestion

Subsequent research is suggested using oral interviews that allow for dynamic probing, repeated classroom observations, video recordings of teacher-child interactions, and analysis of learning documents. A mixed-methods approach is also important to test the effectiveness of the strategy. The qualitative component can identify the forms of scaffolding, questions, and integration that actually arise during learning, while the quantitative component can measure changes in a child's early math and science abilities through early-end assessments or appropriate comparative designs. Subsequent research can also compare groups based on experience, education, training, class size, and institutional conditions to test when relational integration is most likely to be implemented consistently.

4. CONCLUSION

This study shows that, based on the reports of 10 Seven interrelated components of mathematics-science integration through play were identified by the study based on written self-reports from ten early childhood educators: goal-oriented planning, relational integration, questioning and prediction, scaffolding and child agency, environmental materials, formative assessment, and professional learning. Its main addition is the idea of relational integration: rather than just appearing alongside science in the same activity, mathematics plays a functional role inside science research through counting, measuring, comparing, classifying, or representing findings.

In terms of pedagogy, this idea provides educators and organisations with a standard for matching goals, resources, enquiries, scaffolding, and evaluation in

integrated play. Experience may encourage more layered strategy articulation, but professional context and training are equally important, according to the descriptive comparison across participants. These conclusions only address stated misunderstandings and behaviours; they don't show implementation fidelity or learning outcomes for kids. To examine the enactment and consequences of relational integration, future research should combine interviews with repeated observation, interaction logs, learning documents, and child outcome measures.

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6. AUTHOR CONTRIBUTION STATEMENT

The author is responsible for the study's conceptualization, research design, development of research instruments, data collection, data analysis, interpretation of findings, literature synthesis, manuscript drafting, revision, and final approval of the published version. The author bears full responsibility for the integrity and accuracy of the work.

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