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Supporting Early Math Learning Along a Continuum of Guided Play

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Abstract
The early years of education are a crucial time to develop a strong foundation of critical mathematical skills. A growing body of research continues to demonstrate that this foundational knowledge can be successfully built through teacher-facilitated, or guided, approaches to play. Despite its benefits, the implementation of guided play is relatively uncommon, as educators have expressed uncertainty regarding how to support guided play within the realities of classroom practice. The current study addressed this central challenge through qualitative inquiry, and identified three overarching approaches, each with specific strategies for implementation, that educators used to guide children's play to support early math learning. Results also identified how guided play is situated within an ongoing and iterative process of play, whereby educators play a crucial role in supporting children's learning before, during, and after periods of play. Illustrative examples of these approaches and strategies for guiding play will be shared and discussed relative to their potential for supporting educators within their practice of integrating teacher-facilitated play and early mathematics learning.

Keywords Mathematics · Play-Based Learning · Guided Play · Kindergarten

Early math ability is a powerful predictor of future academic learning and opportunity (Duncan et al., 2007). To teach early math skills, many kindergarten programs world-wide endorse (Tafa, 2008) and in the case of Ontario, mandate, play-based pedagogy [Ontario Ministry of Education, (OME) 2016], yet all play is not equal when it comes to math learning. Corroborating evidence from theoretical and experimental studies demonstrates that a specific type of teacher-facilitated play, called guided play, leads to greater math learning gains than traditional approaches like direct instruction or free play (Alfieri et al., 2011; Fisher et al., 2013). While this laboratory-based research suggests that children's math ability thrives when teachers and children meet in the middle between free play and direct instruction, classroom-based research shows that guided play is uncommon in practice (Wickstrom et al., 2019) as educators express uncertainty in how to follow children's lead in play while also directing play towards targeted academic goals (Pyle et al., 2018). Further work is needed to understand how teachers are successfully translating theory into practice by optimizing the middle ground of guided play to support children's early math learning within the realities of classroom practice.

Literature Review

A contemporary conceptualization of play as a continuum describes how play can range from free play (i.e., entirely child-directed), to guided play (i.e., collaboratively led), to teacher directed play (i.e., entirely adult-directed) (Pyle & Danniels, 2017). The concept of guided play, in particular, has been difficult to define in the literature (Weisberg, 2013), but has gained clarity over recent years (Jensen et al., 2019; Skene et al., 2022; Zosh et al., 2018). In essence, definitions of guided play have described a balance between child-autonomy and adult-facilitation within playful contexts. Weisberg et al. (2013) were among the first research teams to highlight the potential of guided play to support young children's learning. Through their work, guided play has been defined as play that remained child-directed, but incorporated elements

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of adult scaffolded learning objectives (Weisberg et al., 2013). Broadly, Weisberg et al., (2016) described two approaches to guided play. In the first approach, educators observed children in free play and encouraged children to extend their interests through questioning and commenting (Weisberg et al., 2016). In the second approach, the educator designed a playful setting, intended to target a specific learning goal, and then allowed the child to freely engage in the activity (Weisberg et al., 2013, 2016). While adult-facilitation is present in more of a passive way, Weisberg et al.'s (2013, 2016) view of guided play prioritizes child-autonomy by continuing to describe the play as child-directed and cautions against adults "co-opting" the play (Weisberg et al., 2013).

Jensen et al., (2019) described similar approaches to guided play, and named them initiating and extending, respectfully. In their work, Jensen et al. (2019) described how initiating refers to activities that are created by an educator and then actively directed by the children, whereas extending refers to contexts in which children are engaged in playful activities and then adults enrich or scaffold these contexts to help students reach their intended goals. Zosh et al., (2018) pushed Weisberg et al.'s (2013, 2016) conceptualization of guided play further, highlighting higher levels of adult involvement by situating guided play in the middle between free play and direct instruction and suggesting that guided play borrows techniques from direct instruction to help children focus on specific learning tasks, while still acknowledging the child as an active participant in their learning. Importantly, Zosh et al.'s (2018) work emphasizes how guided play provides an opportunity for children to engage in learning that remains engaging, meaningful, socially interactive, iterative, and joyful.

The potential of guided play has quickly gained interest and has been studied relative to a wide range of early learning skills, including mathematics. In particular, teacher-led approaches to guided play have been shown to lead to statistically significantly greater gains in number naming, counting, and applied problem solving in four- to six-year-old children compared to age-matched peers that were not exposed to a guided play-based math intervention program (Cohrssen & Niklas, 2019). A seminal study by Fisher et al., (2013) demonstrated that when kindergarten-aged children were exposed to guided play pedagogy they learned, and retained, statistically significantly more novel math knowledge about geometric shapes, than children who learned about the same content knowledge through either free play or direct instruction (Fisher et al., 2013). The general finding that guided play leads to greater math learning gains, when compared to either free play or direct instruction, was corroborated by a systematic review and meta-analysis which demonstrated that guided play interventions had a statistically significant positive effect on young children's math skills including shape knowledge and spatial vocabulary (Skene et al., 2022).

The field of early math learning is broad and complex, and includes a multitude of foundational skills, such as counting, addition, subtraction, measurement, patterning, probability, and geometry (Clements & Sarama, 2014). Within the context of this study, early math learning will be broadly grouped into two overarching skills of number sense and spatial reasoning, as these foundational skills are both widely discussed in the research literature (Clements & Sarama, 2014; Moss et al., 2016; Skene et al., 2022), and are the core skills presented in the kindergarten curriculum in which this study occurred (OME, 2016). Specifically, Clements and Sarama's (2014) work on these broad, yet critical, foundational early math skills will be used, as their work has not only thoroughly reviewed the existing research on young children's early mathematical skills and competencies, but has also been widely accepted in contemporary research literature (Monteleone et al., 2023). Furthermore, their work is particularly appropriate for this current classroom-based study, as it emphasizes the application of early mathematical skills in classroom environments (Clements & Sarama, 2014). Specifically, number sense involves a child's ability to identify number and develop numerical operations (e.g., counting, addition, subtraction, measurement, patterning), while spatial reasoning includes the ability to manipulate and communicate about objects in space (e.g., use spatial langue, navigate body in space, mentally represent and manipulate images) (Clements & Sarama, 2014; Moss et al., 2016). Within a classroom setting, number sense may look like a child's ability to count toys, to add small quantities together, or to recognize patterns in their environment, while spatial sense may look like a child's ability to identify shapes in their classroom, to solve a puzzle, or to pack up their backpack at the end of the day.

While the existing research provides a strong foundation that is crucial for our understanding of the power of guided play for math learning, many of the studies occurred within highly controlled laboratory settings, which differ substantially from real life classrooms, and thus educators are faced with a unique problem regarding how to implement guided play to support math learning in practice. Studies that have examined this topic have found that while guided play is touted as best practice in the literature, educators face difficulty translating theory into classroom practice, as teacher-directed forms of math instruction take precedence (Wickstrom et al., 2019). As such, the current study worked directly with practicing kindergarten educators to understand the approaches and strategies they used to successfully implement guided play to support math learning in kindergarten.

Method

Data Collection

The research team lead an overarching study that was divided into two phases. The current study reports upon Phase 2. Participants for the current study were purposefully selected from Phase 1, which focused on educators' perspectives of play and math learning in kindergarten. In Phase 1, participants were invited to complete an online survey about their perspectives on play, math, and the integration of play and math. Participants who responded with the perspective that play can be used to support academic learning, including mathematics, and described actively collaborating with children in play were invited for follow up interviews to understand their perspectives and practices in greater depth. Inclusion criteria required that all participants were either a current or former kindergarten educator (certified elementary teacher or registered early childhood educator), and had completed, or were currently completing, a permanent or temporary contract in a kindergarten classroom. Both Phase 1 and Phase 2 of the study received ethical approval from the University of Toronto's Ethical Review Board and all participants gave written informed consent prior to participation.

In the current study, 10 participants completed virtual semi-structured interviews (Leavy, 2014). The semi-structured format ensured that all participants answered the same questions while also allowing flexibility to explore emergent ideas and ask follow-up questions (Patton, 2014). All participants were asked the same six core questions: (1) Can you tell me about your experience learning math as a student?, (2) Can you describe approaches to math instruction in your kindergarten classroom?, (3) Can you describe approaches to play-based learning in your kindergarten classroom?, (4), Can you describe how you might collaborate with children in the context of play?, (5) Can you describe an example of how you collaborate with children in play to support their math learning?, (6) Is there anything else you'd like to share with me about play and children's math learning? All interviews lasted approximately one hour in length and were transcribed verbatim.

Data Analysis

Data were analyzed in two phases. In the first phase, all interview transcripts were deductively coded to identify all instances of guided play. As this project addressed the use of guided play to support math learning, only contexts that involved collaborative play with integrated math learning were analyzed. Early math learning was broadly conceptualized to encapsulate any math activity that related to number sense (e.g., counting, measurement, patterning) and spatial sense (e.g., geometry, spatial vocabulary) (Clements & Sarama, 2014). These broad and overarching skills of number sense and spatial reasoning were chosen as they are not only commonly accepted as critical foundational early math skills in the research literature (Clements & Sarama, 2014; Moss et al., 2016; Skene et al., 2022), but are also the core math skills presented in the curriculum in which this study took place (OME, 2016). As such, these foundational skills of number sense and spatial reasoning are common mathematical skills the teachers in this study support in practice and could therefore describe in detail during the interviews of this current study. This part of the analysis was theory-driven, and used a widely agreed upon definition of guided play, play that is to some degree mutually led by child and educator (Pyle & Danniels, 2017; Zosh et al., 2018), to guide the deductive coding framework. For example, any data extract that referenced educators' involvement in play (e.g., collaborative play, mutually-directed play, learning invitations, teacher facilitated games) were compiled into an overarching category called "guided play".

After all instances of guided play had been identified and isolated under the umbrella code of "guided play", all the collated data extracts were then revisited and broadly grouped into categories based on the level of child and adult involvement. For example, collaborative play that was mainly child-led, mutually-led, or educator-led. This grouping approach was guided by theoretical definitions of guided play that currently exist in the literature, as guided play has been described as a continuum (Pyle et al., 2024) that can be child-led, mutually led, or educator-led (Pyle et al., 2017) and has been an accepted method for analyzing and presenting qualitative data in previous research (Wickstrom et al., 2019). This stage of the analysis generated three overall approaches to guiding play; *extending, facilitating*, and *inviting* children to play, which reflected play that was child-led, mutually led, or educator-led, respectively.

The second stage of analysis then inductively (Patton, 2014) coded the data extracts within these three approaches to guided play (i.e., extending, facilitating, inviting), with the aim of identifying specific strategies educators used to implement these three general approaches. While there was a guiding question, or focus, to this inductive stage of analysis, the specific strategies that emerged were organic to the data set. This stage of analysis could be considered more data-driven, as opposed to theory-driven, as there is currently no theoretical framework or definition available in the literature to deductively code for specific strategies that educators are using to implement guided play, hence, the purpose of this study's research question (i.e., *how are kindergarten educators facilitating guided play to support*

children's early math learning?). Results from this stage of the analysis identified 16 specific strategies educators used to facilitate guided play and math learning, which were situated within general approaches to guided play. More so, this phase of analysis identified how guided play is part of an ongoing and iterative process of play, whereby teachers take an active role before, during, and after periods of play to support students' learning (Fig. 1).

Results

By comparing and combining codes across all participants, teachers described three approaches to collaborating with children through guided play, which ranged from lower to higher levels of adult-facilitation. These three approaches were also situated within an overarching and iterative process of play, where educators were involved before, during, and after periods of play to guide student learning. The three approaches to facilitating guided play, each with specific strategies for implementation, will first be shared to demonstrate how educators can support early mathematics learning along a continuum of guided play. Next, these three approaches will be contextualized within a larger and iterative process of play, to demonstrate how educators integrated math learning throughout an ongoing and comprehensive approach to play in kindergarten.

Approaches for Implementing Guided Play: Extending, Facilitating, and Inviting

Extending

The most common approach to collaborating with children in play was through extending the play and involved the highest level of child-autonomy. In this approach, children created a play scenario, such as playing "restaurant", and the educator joined into this child-generated play context to identify and extend math learning. Teachers discussed four common strategies for extending play to infuse and support math learning: offering, commenting, joining, and questioning.

When **offering**, the educator observed children in play, identified a natural extension, and then shared, or offered, this extension to the children. It often involved offering new materials, such as a cash register, toy money, or writing materials, to help the children integrate number knowledge into their play. Teacher 3 explained her rationale behind using offering as a strategy for extending child-led play, *"Just thinking about the materials they're using. Do you have something else that you could offer them or something that you already talked about that can tie in and make a connection to the thing that they're doing?"*. Offering involved lower levels of adult facilitation while maintaining higher levels of child autonomy, as the children decided how they would accept the offer, if at all.

Educators used **commenting** to make specific mathematical skills explicitly known during play. For example, Teacher 3 illustrated how she used commenting to draw students' attention to spatial reasoning and measurement skills within

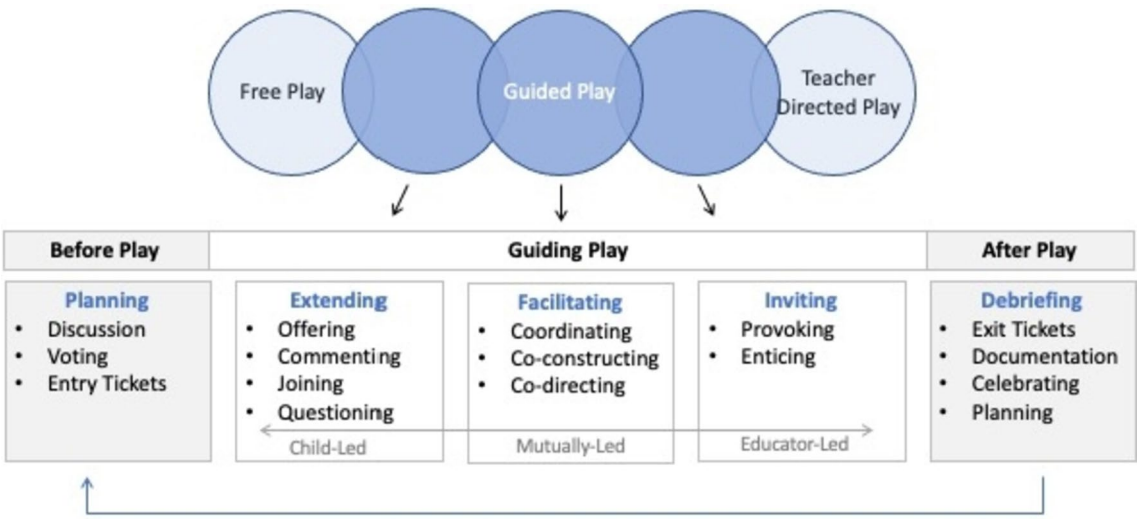

Fig. 1 Approaches and strategies for guiding play

children's block play by explicitly using spatial language, such as "on top", to describe their structures.

> *I think commenting too. So, I've been trying to think more about commenting on things and not just questioning that needs them to respond, that will interrupt their flow of play... So, maybe they have built something in the blocks area saying, "oh, this looks very tall" or "it looks like you've added this on top." More describing the play.*

By commenting on children's play, educators drew children's attention to specific attributes within child-led play, such as size and comparison, to highlight, reinforce, and introduce new mathematical ideas.

Educators also extended child-initiated play by **joining** children in play to direct the play towards math learning. For example, Teacher 3 described joining play as a customer at a pizza store, to strengthen students' developing number sense and understanding of value by asking about the cost of specific items.

> *Joining the play, you can either be prompting and asking questions, or joining as a play participant. So that might look like, you know, you're in the dramatic center and you're going to take on the role as a customer and you can kind of start to prompt the students, by saying, "Ok, I'd like to purchase a pizza… how much does it cost?". And then kind of having that dialogue to see where they take it from there so that you can insert those learning opportunities.*

Through joining the play as a participant, educators were able to influence the direction of play towards mathematical learning goals, while still following children's interests within play.

The most commonly described strategy to extend child-initiated play was through ***questioning***. Most commonly, teachers used questioning to understand what children were doing in play, to identify math learning, and to challenge or push their mathematical thinking further. Teacher 1 described using questioning when children were playing with loose parts, to better help identify the math learning in their open-ended play, *"I'd have her tell me, 'Well, what was your sorting rule? How do you know this one belongs here?' She could explain what she had done"*. Through questioning, Teacher 1 was able to understand what the child was doing in play as well as identify and communicate the data management skill of sorting.

Extending children's play, using a variety of strategies like offering, commenting, joining, and questioning allowed educators to collaborate with children in the context of play to support their math learning. This approach to guided play had the highest level of child-autonomy, as the play context was initiated by the children, and the lowest level of adult-facilitation, as the educator made minor modifications to the play context.

Facilitating

The second approach for supporting math along a continuum of guided play was through facilitating children's play. Here, educators worked alongside children in play to help them ask and answer questions, to explore new ideas and skills, and to help them accomplish their goals in play. Teachers discussed three strategies for facilitating guided play: coordinating, co-constructing, and co-directing inquires.

When **coordinating** play, teachers met children within their play and helped them organize their thoughts, reduce their cognitive load, and refine their ideas to help accomplish specific goals for play. Often, the educator joined children in play to help them breakdown their objectives into more feasible goals that still reflected their interests and intentions. As the teacher is helping children to coordinate their play, they are also guiding the play towards math objectives, or inserting math goals into what the children have already created. For example, Teacher 7 described helping children to plan for a Halloween party by helping them to identify mathematical skills, such as counting and one-to-one correspondence, to ensure they had enough materials for every student at the party.

> *So, it's Halloween… and they told me, "Well, we want to have a party and we want these things: cookies, drinks, scary punch, the box with the spaghetti that feels like worms... And that's when we started to see… you need numeracy for that, based on, "we need to know how many kids are in our class?"*

By helping to coordinate children's goals for play, teachers facilitated math learning within collaboratively directed play. Teachers also facilitated guided play by **co-constructing** with children. While facilitating, the teacher joined children in play to help them build structures, to help the children accomplish tasks, and to help draw their attention to key features to support their spatial thinking and geometric language. Building with children also engaged them more deeply in the learning process than if either the child or teacher had built the structures independently. Teacher 5 described how children's engagement with spatial manipulation was enhanced by involving children in the process of building a rocket ship out of a cardboard box.

> *It feels more meaningful for them. I kind of wonder if I had painted it on the weekend and it just looks like a rocket ship and they never saw the before, would it have lasted as long? If it would have been as fun to play with? In both ways, it's like, "Okay, it would be kind of cool if they just saw a rocket ship come to*

class." But I feel like they really did enjoy the process of making something.

Lastly, teachers described facilitating guided play by **co-directing inquires.** With this strategy, teachers helped to support the inquiry process, often initiated by students, to deepen their learning and interest in a topic. Throughout the inquiry process, the teacher would intentionally direct the learning, questions, and activities towards mathematical goals. Teacher 5 described facilitating a student inquiry on pets and animals, by supporting children to turn their drama center into a veterinary clinic, which they used to learn about different animals, how x-rays work, and how to care for their pets. Throughout the inquiry, Teacher 5 initiated and supported several mathematical conversations that strengthened students' number sense, by discussing how number relates to different attributes, such as age and size.

And then asking them, in terms of building on that inquiry, what should we add next? Because they have really good ideas…And then getting some good questions. [For example] *someone brought in a dog and* [it] *was 4 years old and it was a big German shepherd and one of our students is like, "my dog's 12 years old and it's really small" and you're like, "oh my, so age doesn't correspond with height." So, getting that community in-flow at addressing their questions… but you can connect it back to math.*

Facilitating guided play using strategies like coordinating, co-constructing, and co-directing inquiries, allowed educators to follow children's interests in play and to help children accomplish their goals in play, while also directing the play towards mathematical learning goals. Facilitating involved similar levels of child and adult input, or direction, over the play.

Inviting

The last approach teachers used to guide play was by inviting children to play. In this approach, educators created a play environment, game, or activity, and then invited the children to join them in this playful creation. Often, this playful context had a very specific goal, for example practicing counting, exploring measurement, or learning math vocabulary, that was determined by the educator. Inviting could be conceptualized as the inverse of extending. While extending is child-created and educator-extended, inviting is educator-created and child-extended. Teachers in this study discussed two strategies for inviting children to guided play: provoking and enticing.

Provoking was the most common strategy for inviting children to guided play. With this strategy, teachers would set out activities, signs, or clues that would serve as a provocation or inspiration for play. Sometimes these provocations would be more closed-ended, for example, "*matching the number and the symbol to the items"* (Teacher 7) and sometimes they would be more open-ended, for example leaving out *"10 frames and whole bunch of loose parts"* (Teacher 8). Teacher 3 explained various approaches she used for setting up provocations in her classroom to focus on particular mathematical skills, such as geometry:

I'm setting up - we call them in our board, learning invitations - which are essentially provocations. Sometimes based on where students needed more practice. Sometimes just kind of if we had a focus in mind of, you know we are kind of working a little bit more on shapes right now or geometry. So, setting up materials sometimes with a question that was very specific and very closed. Sometimes just leaving materials with the opportunity for students to take it in their own direction but in ways that there could be mathematical elements.

The second approach to inviting children to guided play was by **enticing** them to engage in an educator-created play context. With enticing, the educator created a highly engaging, and novel play context to attract the children into play. While it is very similar to provocations, provocations were used as everyday classroom activities, while enticing was reserved for special events and activities, and involved the creation of a much more complex and enriching play scenarios. For example, during a morning meeting, Teacher 4 showed her students a picture of a giant two metre cow. The children were really interested in this cow and had many questions about why it was so big. When the students were in gym, the teacher drew and cut out a scaled diagram of the cow and left it out, along with some rulers and pencils, for the children to explore. This led to an ongoing investigation of measurement and scale, as described by Teacher 4:

So there's a giant cow in Australia…he's two metres tall… So, I showed them a picture and said, "hey, there's a cow and it's really big." And they went, "really big?" and I went "ya". So, I drew it and I put it out. And I just left it on our front bulletin board and I made a ruler...I realized that you could teach a lot of math in such a cool way… because there's a number line and measurement. But they got into it. So, we just added. There was a t-rex, we made a streetcar at one point. But they were asking these questions, and I was like, "I don't know… let's figure it out!"

Teacher 4 capitalized on children's interests in animals and their questions about size to entice them into an inquiry on scale and measurement, by strategically placing out novel and exciting materials to engage children in guided play.

When inviting children to guided play, teachers used provoking and enticing as key strategies. This approach to guiding play had the highest levels of teacher-facilitation, while still leaving room for child autonomy and choice. With inviting, the educators created a playful context and then invited the children to engage and extend the learning within this playful activity.

An Iterative Process of Play: Planning, Guiding, and Debriefing

Play is commonly described as an iterative process of wondering, discovering, hypothesizing, and revising theories that underpin learning (Zosh et al., 2018). Teachers in this study described three approaches towards intentionally facilitating an iterative process of play to support student learning; planning, guiding, and debriefing, which occur before, during, and after play, respectively. Taken together, these three approaches helped to support children through a systematic process of learning through play and aligns with descriptions of play as an iterative process of learning for young children (Zosh et al., 2018).

Before Play: Planning

The iterative process of play began with educators helping children to plan for and consider their intentions for play. Planning involved several strategies including, class discussions, voting, and entry tickets.

The most common strategy for planning involved the facilitation of **class discussions**. As a class, the educator facilitated a discussion about students' interests, inquiries, and questions, and would help to connect their wonderings to different play opportunities within the classroom. Teacher 2 explained, *"We always kind of started with a wondering. So, what are you wondering about in your play? Is there a question you have that you're wanting to solve*?".

Following these class discussions, the teacher would then commonly facilitate a **class vote** to determine the purpose of various classroom spaces. Through this process, the educator further strengthened the connections between children's interests and opportunities for enriching play experiences within the classroom. For example, Teacher 1 described facilitating a class vote to decide what the drama center should transform into:

> *Well, at circle time we would determine what should the drama area become next... And then once they voted and knew what it was going to become, I would ask them, "what materials are we going to require in order to make this happen?" They would come up with a list and they could bring it in from home, or I could bring it in, or whatever we had.*

Teachers also took a more direct role in helping children prepare for play by asking them to complete **entry tickets** before joining open-ended centres. Often, this was done to help children expand the possible ways they engaged with a centre. For example, Teacher 10 described asking children to draw a blueprint of a structure before entering the block centre, to help children think critically about what they were going to build and to help support them in their planning process:

> *If they want to go to a certain center in the classroom – let's say the building center – during play, we did a lot of "well, ok, let's draw a blueprint, first". And they all have blueprint books, that I make for them at the start of the year. And their blueprints get more and more detailed as the year goes on. So, at the start, they are just kind of circles, but then they really start to understand the classroom, and then it's a lot of, "well, how many* [blocks] *do you need for that?". Like, how many big blocks should we get out? So, they end up labeling them, and that's a lot of their literacy skills as well.*

Planning for play is an important part of the evolving and iterative process of play. Here, teachers took an active role in helping children determine, organize, and prepare for their learning and exploration in play. This planning was then actualized through educators' involvement in guiding children's play.

During Play: Guiding

While the approaches to guiding play (i.e., extending, facilitating, inviting) have been described in detail above, it is important to reiterate the role of guiding children's play within the larger, iterative, process of play itself. The examples previously discussed illustrate the crucial ways in which educators guide play towards academic goals, integrate opportunities for new learning, help children make connections, and apply their learning in play. In doing so, the educators helped children generate questions, form hypotheses, test, and revise learning through play. Educator involvement in play, to guide, support, and extend learning, is an essential component that makes this iterative, authentic, and meaningful approach to student learning possible.

After Play: Debriefing

After play occurred, educators would often gather the class to debrief their play and provide an opportunity to review, reflect, and consolidate their learning. Teachers discussed using four strategies to help children debrief their learning following play; sharing documentation of play, celebrating the learning, exit tickets, and planning for future periods of play.

The most common strategy **was sharing documentation of play**, as the teacher facilitated a whole class discussion to share any documentation (e.g., photos, videos) that was recorded while children were playing. Teacher 2 described sharing her documentation of play to help students reflect upon what they learned in play:

> *At the very end of that round of play we would come back and be like "So, were your questions answered? Did you achieve what you wanted to? We would go to the documentation that I took and be able to have a chance to explain it to our peers."*

Teacher 2 also used this debriefing as an opportunity to *"use the kids as experts"* and invite them to share and explain what they had done in play. Through these discussions, children and teachers were able to celebrate the learning and accomplishments that children made in play.

Celebrating students' learning in play also inspired children to share their ideas, and approaches to play to support the learning of other students. Teachers commonly facilitated this student-to-student sharing, by suggesting students use developmentally appropriate exit tickets as part of their centers. In a separate example of building, Teacher 4 described guiding a student to create a blueprint of their structure, as a method of supporting and encouraging other students to engage in similarly complex building: "*I love what you're doing, you should make it on paper. Make a blueprint and then other people can make it"*. The use of **exit tickets** allowed students to both record and share their learning in play.

Sharing and celebrating learning helped classes **plan for future periods of play**. Through debriefing, both the educator and children were able to reflect upon and consider next steps for learning. For the educator, this debrief allowed them to consider and plan for the next learning goal for their students, to "*push their learning somewhere, either developmentally or academically*" (Teacher 3). For children, planning for the next period of play allowed them to identify strategies that worked well and possible ways to engage in future play. Debriefing play by planning for future play is a key step that educators used to support an ongoing and iterative process of play within their classrooms. A summary of these approaches and strategies for guiding play to support early math learning can be found in Table 1.

Discussion

This study sought to understand how kindergarten educators were successfully implementing guided play to support early math learning. Results identified a continuum of guided play with three overarching approaches, each with specific strategies for implementation. The findings also identified how guided play, itself, is part of an ongoing and iterative process of play, whereby teachers have a fundamental role in planning, guiding, and debriefing play to support children's academic learning. This discussion will focus on the implications these findings have to support educators in their practice, remaining limitations, as well as next steps to further support educators' integration of collaborative play and math learning in kindergarten.

Research continues to point to the importance of teacher-facilitation of math skills, particularly teacher-facilitation of play to support young children's academic learning (Weisberg et al., 2013, 2016; Zosh et al., 2018). When it comes to children's math learning in particular, the research shows that teacher-facilitation of play, or guided play, is considered to be an optimal approach to supporting children's acquisition and retention of novel mathematical information (Fisher et al., 2013; Skene et al., 2022). In practice, however, educators have expressed uncertainty in how to facilitate children's play so that they may follow children's interests while simultaneously directing play towards academic goals (Pyle et al., 2018).

Findings from this study directly respond to this central challenge. In particular, the approaches and strategies that educators used to support math learning along a continuum of guided play begin to describe a framework for facilitating play to support young children's math development. Not only does this developing framework respond to calls in the research literature to further define what guided play looks like in practice (Wickstrom et al., 2019), but also responds to curricular policy that mandates the use of play-based pedagogies to support children's academic learning (e.g., OME, 2016). Illustrative examples shared in this study can begin to build a roadmap to help guide educators towards collaborating with children in play to support early math learning. Moreso, as the continuum of guided play ranges in level of teacher-facilitation, educators can begin to guide play from a starting point that may be the most familiar to them. For example, some educators may prefer to preserve higher levels of child autonomy while joining children in play, whereas other educators may prefer to plan and achieve specific goals while they collaborate with their students in play. The range in level of child and adult collaboration provides educators with the flexibility to use their professional judgement regarding how to best join and support children in play.

While the research continues to point towards teacher-facilitated play as an optimal method for supporting young children's learning (Skene et al., 2022), competing bodies of research also advocate for different pedagogical approaches, such as direct instruction (Doabler & Fien, 2013). Rather than perpetuate the debate between constructivist and didactic approaches, we argue that there is room for both within a kindergarten classroom and that

Table 1 Approaches and strategies for supporting math through guided play

	Approach	Description	Strategies to Implement
Before Play	Planning	Determine what students will do before they begin play.	• Whole group discussion and decision-making • Class vote • Assign tasks/roles • Enter tickets
During Guided Play (Child-initiated ↑ / Educator-initiated ↓)	Extending	Children initiate play. Educator joins play and extends the play towards math goals.	• Offer materials/ideas • Comment/highlight the math in play • Join the play, insert math • Question children to address math learning • Posing challenges or tasks to extend math learning
	Facilitating	Educator helps children to identify, coordinate, and accomplish their goals in play	• Coordinate ideas, goals, and intentions for play • Provide materials, ideas, and support as needed • Co-direct student inquiries • Help to edit and refine students' ideas
	Inviting	Educator creates a playful context to target a specific math goal. Children join and play within this adult-created context.	• Setting up games/centers • Provocations • Sparking interest and intrigue to entice learners • Modelling play • Facilitating and monitoring games/centers
After Play	Debriefing	Recapping play and consolidating the learning. Plan for future play.	• Share documentation of math learning in play • Celebrate the learning • Exit tickets • Plan for future play

teacher-facilitation of math skills can occur through a variety of forms. The research does demonstrate that direct instruction has a time and place in a classroom, for example, it can be a very effective pedagogy for students who have difficulties learning mathematics (Doabler & Fien, 2013). While we advocate for balance among different approaches to math instruction, we do not mean that there needs to be equal prevalence of these pedagogies in classroom practice. The research is explicitly showing us that while direct instruction can be beneficial to student learning, guided play approaches result in greater math learning gains and knowledge retention (Fisher et al., 2013; Skene et al., 2022). Given these learning gains, and the noted developmental benefits of teacher-facilitated play-based learning (Zosh et al., 2018), prioritizing collaborative playful approaches to math learning in kindergarten may pose an advantage. Such guided play approaches to math learning could also be further enhanced through direct instruction, and with further research, we can begin to unpack the ways in which teacher-facilitated play and direct instruction can be integrated or coexist within kindergarten classrooms. Further research could explore

what combinations or proportions of these pedagogical approaches may best support students' math learning.

While this study provides an initial framework for implementing a continuum of guided play to support early math, more work can be done to further identify approaches and strategies for implementing guided play. Specifically, this line of work could involve collecting data from more educators as well as conducting classroom observations to gain a clearer understanding of what educators are successfully doing in practice to integrate math learning in guided play. Classroom based research, including the collection of classroom observations, offers crucial insights into the ways in which educators are successfully translating theory into practice (Wragg, 2011). There has been an ongoing need to develop strong connections between researchers and practicing educators, and current trends in research continue to demonstrate how rich and practical knowledge can be gathered, that reflects the realities of classroom practice, when we leverage classroom-based approaches to research (Bostic et al., 2021).

Similarly, this classroom-based research, could be used to create evidence-based practitioner resources that systematically integrate critical early math skills with guided approaches to play. While play is promoted in many educational systems to support academic learning (OME, 2016; Pyle et al., 2017), very few evidenced-based resources exist that can help educators implement play, in particular teacher-facilitated play, in practice. Translating knowledge gained from classroom-based research into practitioner-oriented resources is a clear next step towards supporting educators in their practice of integrating early mathematics with teacher-facilitated play. Importantly, a continued partnership between researchers and practicing educators is crucial in order to facilitate these next steps.

In conclusion, this study sought to understand how kindergarten educators are successfully implementing guided play to support early math learning. Results identified how teachers integrated and applied their pedagogical knowledge of play and mathematics through collaborative approaches to play. By varying the levels of adult-facilitation and child-autonomy, educators enacted three approaches to implementing a continuum of guided play to support early math learning: extending, facilitating, and inviting. These three approaches to guided play were also situated within an overarching and iterative process of play, which was facilitated by educators' involvement before, during, and after play to consolidate, connect, and deepen student learning. In doing so, this study not only identified how experienced educators successfully implemented guided play to support early math learning, but also illustrated how guided play strategies can be implemented in practical settings to enrich young children's mathematical learning.

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Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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