ENCYCLOPEDIA on Early Childhood Development

Playing to Learn Mathematics

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Introduction

From the preschool years onward, children with low initial levels of mathematics skills continue to fall further behind their peers.[1] To ensure academic success for all children, these widening gaps must be addressed early. In order to help close content-area gaps, we must leverage the way children learn most successfully to lead to better outcomes.

Subject

Given the importance of early mathematics development for later success, it is crucial to have pedagogical tools that support mathematics learning from the earliest ages. Playful learning—a broad pedagogical approach encompassing free play, guided play, and games— uniquely supports early learning in mathematics by providing an evidence-based method that effectively supports learning in mathematics (among other areas).[2,3]

Problems

Early mathematics competency is a strong predictor of later achievement and success.[4] Yet, across the globe, science, technology, engineering, and mathematics (STEM) skills are rarely introduced adequately in early childhood. Children from lower-income communities experience even lower exposure to STEM related activities than do their middle-income peers—a fact that might account for the gaps in mathematics and spatial competencies present even in early childhood.[1]

Research Context

Hirsh-Pasek, Zosh, and colleagues[5] recently reviewed the literature from the science of learning—including studies from neuroscience, education, psychology, and cognitive science, —and proposed four pillars of learning that describe the ways in which humans learn best. Learning is optimized when children are 1) mentally active in discovering new knowledge; 2) engaged (not distracted); 3) interacting with material in ways that are meaningful; and 4) socially interactive. Importantly, these four characteristics come together in playful learning.

Playful learning includes both free and guided play as well as games. Free play is child-initiated and child-directed,[6] as when children manipulate objects, engage in social interactions with peers or adults, and narrate activities. Even without prompting, many children incorporate mathematics into their independent free play. Seo and Ginsberg,[7] for example, reviewed videotapes of 90 four- and five-year-old children as they played for fifteen-minutes to determine the types of mathematics that occurred organically in everyday play. Six categories of mathematical content emerged: classification (grouping or sorting by attribute), magnitude (comparing the size of objects, such as a tower built of blocks), enumeration (saying number words, counting, subtilizing, or reading/writing numerals), dynamics (putting things together or taking things apart), patterns and shape (for example, making a necklace out of beads with a pattern), and spatial location (describing a direction or location). The range of mathematics that was generated in this study was impressive, as was the frequency with which children spontaneously engaged in mathematics activities. Fully 88% of children participated in at least one mathematics activity during the 15 minutes.

Guided play maintains the exploratory nature of free play while also incorporating developmentally appropriate adult scaffolding[2]—a temporary instructional interaction that supports children's mastery of a specific learning goal.[8] Guided play is, at its core, child-directed. Adults help constrain the discovery of the learning goal by 1) arranging the environment and 2) scaffolding and steering a child to attend to aspects of the environment relevant to the learning goal. For example, a classroom that features a block corner affords children opportunities to learn about spatial rotation. An adult who asks “What happened when you built an even taller tower?” helps the child choose from those alternatives that will favor height as opposed to something like trying to build the longest bridge.

Finally, games that weave content into the course of the play are another playful learning approach. Games offer the potential to increase intrinsic motivation to learn, as well as academic content if that content is integral to the game play, such as the Great Race board game with embedded early mathematics learning.[9]

Key Research Questions

How can parents, teachers, and caregivers leverage the science of how children learn to create a strong foundation of mathematics knowledge through playful learning?

Recent Research Results

Several successful early childhood mathematics interventions employ elements of playful learning to boost children’s mathematics knowledge. Current work finds that guided, rather than free play, is central to this mission.

The Building Blocks PreK curriculum[10] employs games and other play activities to engage children in mathematics learning counting and basic mathematics operations. In one lesson, a teacher and children set up their dramatic play center as a store with a selection of dinosaur toys.[11] The students play shopkeeper and collect money (cards with different numbers of dots to represent dollars) in exchange for the dinosaurs. By counting the number of toys to match the dots on the cards, children practice their counting skills and simple arithmetic while engaging in a pretend play scenario. Research demonstrates that children from disadvantaged backgrounds receiving the Building Blocks curriculum improved their early mathematics knowledge more than children in a comparison group using their regular mathematics curriculum.[10]

With similarly aged children, Ramani and Siegler found that playing a linear number board game—Great Race Game— with an adult for four 15- to 20-minute sessions within a 2-week period increased low-income children’s knowledge in numerical magnitude comparison, number line estimation, counting, and numeral identification. The gains remained even 9 weeks later. By infusing the game with key number sense concepts, the game's playful and engaging elements helped the children increase their mathematical knowledge more than those children who played a similar game without integrated mathematics content. But, materials must be carefully designed and not just any design will do. Laski and Siegler[12] demonstrate that a circular board game that does not emphasize the linearity of number is not effective for extending mathematical learning.

Finally, in spatial learning (an area closely connected to mathematics), Fisher and colleagues[13] found that guided play promoted children's learning about the features of geometric shapes better than didactic instruction or free play. Guided play led to the greatest amount of transfer of shape knowledge to atypical shapes.

Research Gaps

During playful learning, children are given a lead role. Adults who have a learning goal in mind constrain the learning space so that the children's focus lands on the relevant aspects of the material before them. In other words, adults set the mise en place: a term borrowed from the culinary arts, which describes laying out the necessary high quality ingredients before the cooking even starts.[14] Children can then generate hypotheses about an end goal within such a constrained space.[15] Further research is needed to determine why guided play is so effective and whether it works for different age groups and children with individual learning differences.

Conclusions

Early childhood learning experiences can have a powerful impact on children's later life outcomes.[16] Yet, adding more time for drill and testing has not proven an effective strategy as reflected by both paltry international testing scores for many countries as well as achievement gaps between different demographic groups within the United States. While there is no question that even preschool children profit from a strong curriculum in math, literacy, and science,[17] better outcomes are likely if this curriculum is delivered with an age-appropriate playful pedagogy.[18] The playful learning approach offers the opportunity to deliver rich mathematics learning through child-directed, adult-supported play activities.[6,19] Research from the science of learning indicates that when learners are active, engaged, meaningful, and socially interactive, learning can soar. The challenge then becomes how best to implement this in classrooms and in homes so that all children reach their mathematics potential. By fostering STEM acumen from an early age, societies can increase the likelihood that they will be able to fill the ever-expanding pool of STEM jobs.

Implications for Parents, Services and Policy

Playful mathematics learning is not a novel concept in many of today's homes, classrooms, and communities, making this approach readily implementable. Children already play with blocks, create pretend play scenarios, and interact with digital apps on a regular, if not daily, basis. By designing these experiences with specific learning goals, child's play may be transformed into playful learning. Through the application of principles culled from rigorous empirical research in the science of learning, playful learning (i.e., free play, guided play, and games) presents an evidence-based method for sharing mathematical content with young children. By starting early, caregivers and educators can help instill a love of mathematics that may lead children not only to mathematics achievement today but also towards a STEM career tomorrow. Research repeatedly finds that play is more than just fun; it is a valuable educational tool. In particular, adult-supported guided play and games help children learn mathematical concepts in a way that "sticks" and transfers to new problems.

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