Mathematical Experiences for Children Built Upon Play and Relationships

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Abstract: By observing preschoolers, we can better understand that mathematics is already a part of their surroundings. Research supports that children have an innate sense of pre-mathematical skills that are observed during play. Early Childhood Educators are the bridge between children's pre-mathematical understanding into informative primary mathematical concepts. Mathematical experiences for children should be built upon play and natural relationships in daily activities. Teachers should design their environments then lesson plan by individualizing math activities and materials in interest areas for open-ended exploration. When educators understand math concepts, they are better able to observe, analyze and evaluate children's learning and development, and then plan specific individualized activities to foster children's mathematical progressions.

Introduction

Play is serious learning for children. The idea of "play" is acting upon the direct object and child, and less about academics. It is an activity child engage in for enjoyment and recreation. Play is a useful strategy and a necessary tool in early childhood education. Children who are engaged in play pursue their purpose and problem solve challenges which are within their capabilities. When teachers introduce a "problem," children should be able to approach it in many ways. When several children confront the same situation, they will engage in problem solving producing different solutions and learn from each other through playing. Furthermore, play promotes thinking and learning skills along with other learning areas. Mathematical learning is related to the effective use of play within children's natural relationships with children and adults.

Mathematical Framework and Objectives

Children can acquire basic mathematics concepts to use in daily life and enhance their thinking and problem-solving skills when they are introduced to mathematics in early childhood education. To support this theory, Dr. Benjamin Bloom led a group of experts in educational evaluation promoting higher forms of thinking in education, such as analyzing and evaluating concepts, processes, procedures, and principles rather than just remembering facts (rote learning). Bloom developed a taxonomy or classification system of educational objectives which are a clear description of the teacher's educational intentions for students (Bloom, 1956). Bloom's taxonomy engendered a way to align educational goals, curricula, and assessments that are used in schools, structured the depth of the instructional activities and curriculum that teachers provide for students, and helped teachers understand how to enhance and improve instructional delivery by aligning learning objectives with student assessments.

Bloom's objectives are divided into three domains: cognitive (knowledge), affective (growth in feelings or emotional areas), and psychomotor (physical skills assessed with a checklist). For example, most 3-year-olds are primarily concrete thinkers. This means that their speech and thinking are quite literal, often focusing on what is physically in front of them. Some 3-year-olds might not be able to answer complicated questions that older children can. For example, a 3-year-old may begin recognizing shapes, and sort objects by color, shape, size, or purpose. Around the age of 4, more advanced concepts of thinking occur such as comparing/ contrasting of items using classifications like height, width, and size and understanding that numerals stand for number names (5 stands for five).

When applying Bloom's levels of questioning, many 4-year-olds and some 3-year-olds will understand the abstract concepts comprising the higher levels of questioning, such as analyzing, evaluating, and creating. Not all preschoolers will understand these concepts, but teachers can still use Bloom's Taxonomy to ask preschoolers higher-level questions. Through ongoing observation and assessment, teachers keep track of their students' activities and skills, and plan their questions to match a child's current level to encourage progress. Bloom (1956) explains there are six basic objectives listed in the original Taxonomy of the thinking and cognitive domain:

Remembering (Knowledge): Recognizing something with or without understanding it.

Understanding (Comprehension): Grasping material without relating it to anything.

Applying: Using a general concept to solve a particular problem.

Analyzing: Breaking something down into its parts.

Evaluating: Judging the value of methods or materials as they might be applied in a particular situation.

Synthesis: Creating something new by combining different ideas (Bloom, 1956, pp. 201-207).

Developmental Stages and Mathematic Outcomes of Play

Children demonstrate an interest in math well before they enter school. They notice basic geometric shapes, construct, extend simple patterns, and learn to count. Play-based programs such as Head Start emphasizes that mathematics is broader and deeper than just practicing counting and adding. Allowing children to engage in the practice of play invites them to experiment with mathematics without the worry of making a mistake. This is beneficial for learning because play builds a strong sense of self confidence. Listening, negotiating, and compromising are challenging for 4- and 5-year-olds. As explained by Piaget & Elkind (1968), during the sensory and pre-operational stages from age two to seven years, children do not have the mental maturity to group mathematical concepts presented by words and symbols alone.

Children need experiences with tangible items and drawings to represent their ideas, which will eventually transform and evolve into potential projects (Piaget & Elkind, 1968). Children will build upon play-based behaviors such as patience and perseverance which in turn will help them gain a deeper appreciation and understanding in their mathematical skill set.

Children in a classroom go on shape hunts, compare sizes of colored counting bears, and count out objects by their teacher's instructional practices. How often do they do that through play? What does it mean for a child's development? Children should have regular and meaningful opportunities to learn, discuss, and use math throughout the school day. Early math instruction should build on children's current understanding and lay the foundation for the formal systems of math that will be taught later in school. It is important to point out that within the essential skills of problem solving, reasoning, communicating, making connections, and representing, children learn mathematics content (Copley et. al., 2010). When children are engaged in free play, four areas of mathematical outcomes emerge: Counting/Cardinality, Operations and Algebraic Thinking, Measurement and Geometry, and Spatial Sense and within those areas, six areas of mathematical content emerge:

Classifying: A child takes out all the counter bears from the container and sorts them by size and color.

Exploring magnitude (describing and comparing the size of objects): Children line their shoes up in a row and sort the largest size shoe to the smallest sized shoe.

Enumerating (saying number words, counting, instantly recognizing several objects, or reading or writing numbers): Children count the number of chicken nuggets they placed on their plates at lunch. The teacher constructed a graph with corresponding number words.

Investigating dynamics (putting things together, taking them apart, or exploring motions such as flipping): During a science activity related to motion, children took turns racing cars down a ramp to see whose car traveled further.

Studying pattern and shape (identifying or creating patterns or shapes or exploring geometric properties): At the light table, two children build a five-sided house connecting magna tiles (which are geometric shaped).

Exploring spatial relations: During gross motor play, the children each have a bean bag and while listening to the song they place the bean bag where directed (on head, under shoe, on the table, in the bucket) (Copley, et al., 2010, pp.741-772).

The content indicates the cognition of mathematical development and the four areas of mathematical outcomes as described by Copley (2010). When educators strategize utilizing this tool along with play and daily activities to promote mathematical development, evidence of success overlaps in numerous domains and dimensions.

Developmentally Appropriate Instruction and Experiences Fostered by Research

Copley et al.'s (2010) model is predicated upon many years of developmental theory and research, which suggests that the quality of teacher-student interactions serve as the primary mechanism for student learning (Pianta et al. 2008). This research has depicted a connection between free play, early math skills, and later school reading and math retainment. An analysis of six longitudinal studies showed that early math skills have the greatest predictive power, followed by reading and then attention skills (Duncan et. al., 2007). Number and operations, geometry and spatial sense, measurement, patterns (algebra), and data analysis are standards described in Principles and Standards for School Mathematics, NCTM (2006) and were used to organize discussions of mathematics in The Creative Curriculum for Preschool (Dodge, et al., 2016). The National Council of Teachers of Mathematics (NCTM) publication Curriculum Focal Points (2006) confirms that number and operations, geometry, and measurement are the areas that should receive the most emphasis in preschool.

Understanding the concept of number and operations helps create the foundation of young children's math understanding. Because there is much more to early math than understanding number and operations, educators should offer young children experiences in other content areas. This concept helps prepare them for the different math subjects they will eventually encounter in school, such as algebra and statistics, and help children view and understand their world mathematically.

With a clear understanding of the components of mathematics, teachers will be able to observe children, analyze and evaluate their mathematics learning and development, and plan instruction to help each child progress (NCTM, 2006). These assessments can help both students and teachers improve the work the students are doing in mathematics. Students need to learn to monitor and evaluate their progress. When students are encouraged to assess their own learning, they become more aware of what they know, how they learn, and what resources they are using when they do mathematics. When resources are available to children, they become better equipped to engage in self-monitoring and self-regulation, which are important characteristics of promoting ownership of learning and independence of thought.

Free Play

Free play offers a rich foundation on which to build interesting everyday mathematical experiences. During group time it is important to emphasize activities that allow children to analyze, synthesize, and evaluate. This higher-level thinking expands children's cognitive knowledge. The teacher must plan a fertile environment that is conducive to mathematical explorations which scaffolds with the curriculum. For example, the classroom environment should include unit blocks, a dramatic play area (ex: grocery store), and manipulatives. Children's play with such objects forms much of the pre-mathematical conceptual foundations that children need. To help children build on these foundations for developing mathematical knowledge, teachers must observe children and offer encouragement when necessary.

Math can be individualized on lesson plans then observed through children's ongoing play and assessments. This individualization must include a teacher who is intentional and understands the curriculum, environment, and children's backgrounds along with providing families with guidance to assist with mathematical exploration within the home. When these teaching practices are fostered with play, children can be creative and expand their imagination, build a strong and healthy sense of cognition, interact with the world around them, develop social skills in learning to share and resolve conflicts, practice decision making skills, and finally build confidence within themselves.

Curriculum Implementation

A strong curriculum brings clarity to a school's endeavor; it has practical, intellectual, and philosophical benefits and leaves teachers' room for professional judgment and creativity. The curriculum chosen for many Head Start organizations is The Creative Curriculum for Preschool (Dodge et al., 2016). When teachers consciously set up a successful environment it helps children make choices, encourages them to use materials well, and teaches them to take increasing responsibility for maintaining the classroom. But when is intervention necessary? A useful strategy is to ask whether mathematical thinking is developing or whether it is stalled (Clements & Sarama, 2014). If it is developing, the teacher might observe and take notes, leave the children alone, and talk about the experience later with the children or the whole class to explicate the mathematics. If it is stalled, has the teacher observed the children using the manipulatives or are they bored and not challenged by the classroom materials? For example, when a teacher has observed children not fully utilizing the block area, the teacher may add additional sets of blocks, pictures, graphing paper, along with measurement and writing tools. When the teacher observes children comparing structure height, he/she may ask children what they can use to measure their buildings.

When mathematical thinking is stalled, the teacher should intervene, discussing and clarifying the ideas. Children may have a back-and-forth discussion of whose is the tallest, sturdiest, or better building. The teacher might overhear one child talking about how high their building is while the other intently states theirs is longer (wider). The teacher can intervene and join in on the discussion by asking probing questions such as "how do you know how tall your tower is?" or "that is a really wide structure. Let us measure how wide it is!" At that point, the teacher could engage in "investigative conversation" and ask the children what they see, measure each of the structures with string, cubes or a ruler, document measurements and observations on paper and later discuss the issue with the class as an interesting event. Teachers may also want to work with their students to develop their curiosities and evidence into a full investigative study.

Mathematical Progressions of Learning and Development

Another way to increase mathematical knowledge is to scaffold children's learning from their previous knowledge. Educators should intentionally plan for children's learning and individualize specific math activities based on the child's progressions of development and learning. Children grasp pre-mathematical knowledge within their first few months of life. Infants verbalize or signal when they want "more" food. They know familiar and unfamiliar adults (sorting and classifying). Patterning is when parents use words or phrases from familiar songs that use repetition. This parent/child relationship sets the stage for infants to use their everyday experiences for math connections within their environment.

Research has made a clear link between early math skills and later school reading and math achievement (Duncan et. al., 2007, p. 43). They also conducted an analysis of six longitudinal studies which showed that "early math skills have the greatest predictive power, followed by reading and then attention skills" and continues by mentioning that children's knowledge at kindergarten entry is considered predictive of future mathematics success throughout their years in school. Evidence collected shows that high-quality early childhood education programs can make a difference in children's mathematical learning. In addition, the teacher must observe evidence of children's mathematical skill set as they interact with children around the instructional tasks and thus alter their own knowledge of children and future instructional strategies and paths (Clements & Sarama, 2014).

Overcoming Barriers with Adult Supports

Most children can develop a math skill base despite their family's income level, ethnicity, poverty level, or differing ability. The way we communicate with children and families to present the lesson also plays a significant role for a child learning mathematics. A child with a differing ability will need adaptive materials as well as a specially designed environment, adjusted routines, and modifications/individualization to scheduled activities. This is when lesson plan individualizing is critical.

Adults (whether educators or family members) are an integral part of children's success or failure in mathematical learning. Early childhood educators layer children's formal understanding of math with individualized school-based activities. Teaching teams design the learning environment guided by their curriculum and place math materials in interest areas for child-initiated explorations. Teachers along with support staff later observe and listen to key interactions between children. Teachers ask questions as children investigate, and these specific children may need support in finding out answers. Keeping family members informed of their child's strengths and areas of growth helps to support both the child and the family for the transition into the next school year.

Conclusion

The incorporation of play scaffolded with mathematical skills helps children process the experiences of life. Continued research is important because students from preschool to grade 12 will use these skills in all school subjects, as well as in their personal lives. In the emerging view of mathematics education, students make their own mathematics learning individually meaningful. Important mathematics is not limited to specific facts and skills students can be trained to remember but rather involves the intellectual structures and processes students develop as they engage in activities they have endowed with meaning. When students learn through these experiences, they habituate to confront problems. They reason, communicate, represent ideas, and connect their learning to mathematical content and real life. In short, implementing play to strategize mathematical concepts and operations as described by Piaget and Elkind (1968) is a transition of physical, tangible, and a perceptual database to conceptual, abstract, and hypothetical thinking. Early childhood learning experiences have a powerful impact on children's later life outcomes and are more likely if curriculum is delivered with an age-appropriate playful pedagogy. Learning through play offers opportunities to deliver rich mathematics learning through child-directed, adult-supported play activities. Given the importance of early mathematical development, it is imperative we figure out how best to foster the concepts of play and mathematical learning for all young children.

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