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STEAM
The Science of Sand and Water

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Abstract

Sand and water play provides learning opportunities for young children to experiment with big concepts and fosters scientific inquiry. In using sand and water as a resource for learning, teachers observe preschoolers change and develop in their understanding of physical properties of the materials and see the child's growing sophistication in understanding how the changes the children make affects the outcome of the play. In this article, teachers observe and scaffold children's learning in the sand and water area based on cross cutting concepts from the Next Generation Science Standards and engage children in conversations that incorporate all disciplines.

Keywords: play, STEM, inquiry, sand and water, cross cutting concepts, NGSS

In a corner of the Outdoor Classroom, a three-year old watches droplets he releases from a pipette into the water table, carefully observing concentric circles form with each drop as the pattern repeats over and over again. He says, "Teacher, do you see? Do you see the circles? It's always circles!"

In another area, a group of children dig deep holes and fill them again with buckets of water only to watch the water slowly disappear into the hole. They rush back and forth between faucet and hole only to watch the water disappear repeatedly.

> "Run, run, get more water, the water is going again!"
> "Hurry, the water is running out in the hole. It's almost gone!"

Children can spend hours playing with water. We see it when we give children baths or take them to the beach, and they can show disappointment when they must leave the bath or the beach. Play in the context of school is often limited to recess time or after children have finished an assigned task or activity. Play is a tool not often valued in the context of a school setting. At our school, play *is* the curriculum that enhances our work in literacy, mathematics, and the sciences. We define play as being intrinsically motivated, enjoyable, freely chosen, exploratory in nature, process over product oriented, and non-literal (Lozon & Brooks, 2019). When children play, the teacher follows the child's lead while observing the play in context of learning new concepts.

In many play-based early childhood schools, sand and water play is prevalent and essential. Sand and water play is fun and creates an environment where children engage in mathematical ideas and scientific concepts. It gives them opportunities to practice the behaviors of a scientist or an engineer (NSTA, 2014). At our early childhood school, a mixed-age group of children (3 - 5-year-olds) approach the sand and water play area as a full-body experience. Socks and shoes are immediately removed in preparation for the play, and in the end, their clothes are soaked and muddied.

> "I made a pool, look guys, I made a pool!"
> "It's not a pool. If it were a pool, we could all jump in."
> "I'm digging a path so the water will come all the way over here."
> "But wait, there's only one problem. The water will stop here, we will have to go all the way this way to make it keep going."

One can immediately notice the embedded literacy, while also noting the children's development of concepts as they relate to a real-world context. The child who commented, "It's not a pool," sees a pool as large enough for his body and his friends' bodies to fit. That child can be presented with a different context for pools that causes him to make an accommodation for an existing mental framework. For example, the teachers could then engage in a conversation about "pools of water" with the child if a cup of water or glass of milk is accidentally tipped over at lunch. Perhaps the teachers could make comments about pools of water forming after a rain so that the definition is no longer limited to the knowledge or existing framework of a physical swimming pool. These extensions are organic and stem from the natural play of a child through a context-rich exploration of the child's own choosing. In this example, the teachers used the child's definition and conceptual understanding of the word "pool" to broaden their understandings.

Play often fosters self-initiated scientific inquiry, which introduces children to big concepts through real hands-on learning (Stone, 2016). The child who dug a path to move the water and who commented, "I'm digging a path so the water will come all the way over here," is engaging

with concepts such as form and function, cause and effect, and systems and systems thinking. Yet, educators may miss seeing these concepts develop when children are engaged in play. When we listen to young children, we discover where they are in their learning and what they understand about the properties of sand and water. How does this play help in the understanding of science and math? What did the children gain by repeating their actions over and over? In our preschool, we wonder what the children are thinking; we wonder how we can extend their play; we wonder if pedagogy helps enhance children's learning. How does our knowledge of cross-cutting concepts, developmental continuums, and theory guide our next steps with each and every child we work with at school?

When young learners engage in sand and water play, they are exposed to many concepts and make discoveries for themselves. For example, cause and effect is a concept children observe when they generate changes as they move the sand for the water's path. They observe changes as they pour water and watch it get stuck, move back and/or sink into the sand or continue to move along a carved-out path. Depending on their observations, children can make decisions based on the pattern of the water flow or the movement of the sand. Children can also observe patterns in their sand designs. They might be able to observe that rivers flowing down a sand path continue to move down, but that rivers cannot flow uphill and will sink into the sand. Children can explore and gain exposure to the concept of systems through their play and can observe the behavior of the system. For example, pouring the water into a large hole (which has different paths for escape) shows how the pool of water can be broken up into smaller paths. The concepts of stability and change are ubiquitous as the children play in the sand.

In the multiage outdoor classroom of three- and four-year-olds, we watched as younger three-year-olds filled a hole with water and observed the water disappear. The repetition of filling the hole, watching the water slowly disappear, and then filling the hole again delighted young learners over and over again. The children were unaware of the scientific principles of displacement or absorption as they played, yet through the repetition of such play episodes, the foundation of the scientific principles that govern our world were beginning to form.

In the multi-age classroom, we also saw how our older students who had more experience with sand and water play influenced the youngest learners. Because the older children had spent last year digging and filling sand holes with water repeatedly, they had formed a deeper understanding of the properties of sand and water and were ready to notice new phenomena that affected the outcome of their plans. The four- and five-year-old children searched for ways to keep the water in the sand area to create a little river for their boat play. They had the physical understanding that the water would eventually disappear or move into the sand. Their thinking moved toward the question of how they would keep the water in place so they could use it in their play of floating boats and other loose parts down their river. This authentic inquiry process was initiated through play and owned by the children as they explored questions that arose out of their own curiosity. Also, while the younger three-year-olds used any vessel available to dig, scoop, and fill buckets, the older children knew from prior experience which buckets were the best for filling. They also knew which buckets were the best for carrying water and which shovels were most effective for digging holes and trenches. The older children did not learn this by playing with sand and water on occasion; rather, it was through the repetition of play episodes that deepened their knowledge and understanding and helped them refine their practices.

During the unprecedented COVID year, our outdoor classroom shifted from a large open area in which children freely explored any area for as long, or as short as they liked, to three separate designated play spaces the children visited on specific days at specific times. Initially, this shift was viewed as a constraint. However, when thinking about the importance of repetition for children's learning, it became a possibility; it was a possibility for practicing and repeating play experiences with a deeper focus than before. Not being able to come and go freely had, in a way, given the children time to be more focused in their play.

Through their continued play with sand and water, the children noticed other elements that caused change in their waterways and constructions. They explored, practiced, and repeated their actions to better understand this new information until these processes were internalized. The repetition brought about familiarity and confidence with the once-new phenomena, so children were once again ready to notice new and unexplored occurrences in their surroundings. Over time, the children's play extended beyond digging and filling holes to forming bridges; creating homes for themselves and each other, and animals; and digging a complex system of waterways. The children observed the flow of water through their hand-made waterways and noticed what caused the water flow to stop, such as a friend's foot accidentally stepping into the waterway, helping them become highly aware of their physicality and how their own bodies take up space. Like engineers, children had to explain solutions of an upward incline stopping the water flow or the problem of a foot blocking water from flowing to a different path.

Through the repetition of play episodes with sand and water, the children were building the foundation for later scientific learning. The Next Generation Science Standards' (2014) crosscutting concepts were evident in every aspect of their play. The lines and grooves the children made in the sand became patterns for future digging endeavors. When children mixed sand with water and compared the new consistency to dry sand, they learned the physical properties of sand, as well as cause and effect of water on sand. Children also experimented with cause and effect as they dug and filled holes, stepped into a deep pool with shoes still on, or diverted the water flow away from a friend's pool. Energy and matter were explored as children noticed the water's effect on the sand and adjusted the flow of water into their trenches, as well as the difference between the flow of dry sand compared with how it sticks together when wet. The concepts of scale, proportion, and quantity were investigated through the building of bridges and sandcastles as children experimented with the proper ratio of sand to water to construct their castle. They also learned how to dig a hole for a tunnel so it didn't collapse. Stability and change were experienced every time the children returned to the sandbox, only to find their previous structures and waterways altered or gone completely.

As the children continued to play within the system of sand and water, they became more focused and intentional in their play. While play is process over product oriented, when children are in flow (Csikszentmihaly,1990), they are deeply involved in their activity of creating pools and pathways in the sandbox. Children worked together to create the longest trench as well as the "biggest pool in the universe." Plans were made about where and how they were going to make their "pools" and "homes" for each other and the animals. Rocks were added to trenches to act as dams, and twigs were used to define spaces. The children discussed if and when the trenches should be joined, resulting in a complex system for the water's path to meet each other's needs. Observing and documenting children's play provided a point of reference to analyze what the

children were doing. How are the children using and interacting with the materials? What problems are the children encountering and trying to solve? What possibilities are they testing and what are their theories about what might happen next? By reflecting on children's play, we noticed that the children always dug their paths in the same direction, downhill from the waterspout, which is actually quite strategic. After months of repeated play episodes messing about with sand and water, we decided to offer the children a challenge. During our next visit to the sand and water area, we sat on the edge of the sandbox and wondered aloud whether it was possible to dig a path that went around the tree, which happened to be located slightly uphill from the waterspout. The children eagerly accepted the challenge, which brought new problems to solve, ideas to share, and theories to test.

In conclusion, children's play with sand and water is rich, filled with investigations and experimentation. Children think like scientists as they plan out their investigations and collaborate with their peers. They analyze the cause and effect of their structures, collect the data they have visualized, and construct and design solutions like an engineer. Teachers who see the opportunities for learning through water and sand play celebrate and honor young children's play!

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