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AWE AND WONDER: Mathematics, science, and the outdoors

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The outdoor learning environment shown in the photograph provides a wealth of opportunities for children to develop scientific and mathematical concepts through exploratory play. Features such as the mud kitchen, painted tyres, tree stump seating, and gazebo create multiple invitations to investigate size, weight, forces, and the natural world. For this learning story, the focus will be placed on the mud kitchen area, which allows children to explore the properties of materials, mixtures, and early measurement in playful, hands-on ways.

The curriculum for Wales (2022) emphasizes how crucial play-based learning is during the early years, especially within the Science and Technology Area of Learning and Experience (AoLE). This approach fosters curiosity, problem-solving skills, and hands-on experimentation with different materials. Likewise, the Mathematics and Numeracy AoLE focuses on providing chances to compare, sort and measure in real-life situations. This setting perfectly matches these goals, creating a natural environment where children can develop essential scientific and mathematical knowledge.

Observing Play in the Mud Kitchen

It is a bright afternoon, and a small group of four-year-olds have gravitated towards the mud kitchen in the far corner of the outdoor space. The area contains two large tubs, one filled with water and the other with soil. Hanging on the fence are pots, pans, and wooden spoons.

Child A: "Let's make soup!"

Child B: "We need more water!"

One child begins tipping water from the tub using a ladle, carefully pouring it into a saucepan already half-filled with soil. Another child collects leaves from the nearby bushes to add to the mixture.

As they stir, the children notice how the water changes the soil's texture. The dry soil is crumbly, but with added water, it transforms into thick mud.

Practitioner (joining in): "What do you notice has happened to the soil when you mixed in the water?"

Child C: "It's sticky now—it was dusty before."

Practitioner: "Yes, that's right. The water has changed the way it feels. How much water do you think we need to make it runny instead of sticky?"

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This example shows how professionals can nurture children's curiosity through open-ended questions. The children are learning about states of matter and material changes, while also getting into basic measurement and prediction.

Scientific Concepts Explored

Material Characteristics

The mud kitchen is a perfect place for children to explore the properties of various natural materials.

They discover that:

- Dry soil is crumbly, but its texture changes when mixed with water
- Leaves can float on water, but they get soggy and heavy when mixed into mud
- Pebbles sink in the mixture since they are denser than water

These daily observations relate to the scientific idea that materials have various properties, which affects how they're used. Children are starting to build a basic understanding of solids, liquids, and mixtures.

Reversible and Irreversible Changes

When children mix soil, water, leaves, and natural items, they start to see what changes can be reversed and what can't. Like, you can pour water back into the container, but once it has been mixed with soil, it is hard to pour it back out. This helps the children grasp the basic difference between reversible and irreversible changes, which is an important concept in science.

Measurement and Comparison

Children naturally incorporate mathematical language during mud kitchen play:

- "More water!"
- "It's too full!"
- "We need a little bit."

By tipping and transferring water between different containers, they investigate capacity and volume. By adding scoops of soil or measuring out spoons of water, they participate in comparison and estimation. These activities are in line with the Curriculum for Wales, which emphasizes enhancing numeracy in practical situations.

Practitioner Support and Extension

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Practitioners play a crucial role in extending children's learning without interrupting the flow of play. Strategies include:

- Asking open-ended questions:
 - "What do you think will happen if we add more leaves?"
 - "How can we make the mixture thinner?"
 - "Which container holds the most soup?"
- Introducing new vocabulary: Words such as sticky, smooth, crumbly, liquid, solid, heavy, light, sink, float can be modelled naturally during conversation.
- Encouraging prediction and testing:
 - "Do you think the stone will float or sink?"
 - "Let's try it and see."

This framework helps children to think like scientists, try out experiments, and explore their own ideas.

Possible Extensions with Additional Resources

To deepen the exploration of materials, practitioners might add:

- Measuring jugs and scales to encourage more precise exploration of volume and weight.
- Sieves and colanders to allow children to separate mixtures, reinforcing ideas of filtering and reversible change.
- Different soil types (sand, clay, compost) for comparison of textures and properties.
- Coloured water (using food colouring) to help children see how liquids mix and spread.
- Natural loose parts such as pinecones, shells, or feathers, to extend investigation of sinking, floating, and absorption.

These resources enhance the environment and create fresh chances for children to inquire and explore more.

Links to Curriculum for Wales

Curriculum for Wales – Science and Technology AoLE:

Children are encouraged to be curious about nature, to ask children, and to figure how things work. Playing in the mud kitchen while investigation mixtures and material properties back up the idea that children should "explore their surroundings and understand how things function by getting involved in hands-on, creative and fun experiences."

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Curriculum for Wales – Mathematics and Numeracy AoLE: By filling, pouring, and comparing different containers, children start to grasp basic concepts of measurement, capacity, and volume. This framework promotes using numeracy skills in real-life situations, which is exactly what this play offers.

Curriculum for non-maintained settings (3-7 years): The environment supports the belief that “Children learn best through action”, and through actively engaging with materials. The mud kitchen perfectly provides these chances for sensory, physical, and conative learning.

Learning Story Reflection

As the afternoon goes on, the children are perfecting their recipes. One group opts to create a ‘chocolate cake’ by layering dirt, leaves, and water in a baking tin. Another group is focused on stirring for a long time, noticing how the mix becomes smoother. The practitioner is sitting with them, not leading but watching, listening, and sometimes asking questions. The mud kitchen has turned into a little lab. Here, the children are scientists, chefs, and mathematicians all at once. Their findings are genuine and significant because they come from play. By working with soil, water and natural materials, the children are not just learning about the properties of these materials but also building resilience, creativity, and teamwork skills.

Conclusion

The outdoor setting in the picture provides a rich and meaningful backdrop for nurturing early scientific and mathematical ideas. By concentrating on the mud kitchen, we can observe how children’s playful engagement with soil, water, and natural elements enhances their grasp of material properties, mixtures, and measurements. With attentive support from practitioners and thoughtfully selected extra resources, this space fosters curiosity, experimentation, and discovery – all of which are key to the curriculum for Wales and other early years frameworks. In this sense, the mud kitchen is not just a play area. It’s a place where children cultivate the habits of scientists and mathematicians: observing, predicting, testing, and reflecting – skills that will support them throughout their lifelong learning journeys.

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Name of activity:	Outdoor exploratory play (mud kitchen, tyres, log seating, gazebo, and artificial grass area).
Description of activity	Children engage in exploratory and imaginative play in the outdoor environment. Activities include mixing soil and water in the mud kitchen, climbing and balancing on tyres, sitting, and playing on log stools, and using the gazebo/sandpit area.
Appropriate for which ages and abilities	Primarily suitable for children aged 3–7 years, with adaptations possible for different developmental stages and abilities. Adult supervision required.
Equipment or resources needed	Mud kitchen equipment (pots, pans, spoons, containers), natural materials (soil, water, leaves, sticks, pebbles), protective gloves/aprons (optional), first aid kit accessible.
Any special adaptations for different needs	Provide lower seating or raised surfaces for wheelchair users. Use larger, easy-grip utensils for children with fine motor difficulties. Offer quieter zones (e.g., gazebo) for children who may be overwhelmed by sensory-rich play.
Benefits (Soft/Hard outcomes, Early learning outcomes, Key stage outcomes)	- Development of scientific concepts (properties of materials, mixtures) - Enhancement of mathematical thinking (measurement, capacity, comparison) - Physical development (balance, coordination, fine motor skills) - Social/emotional learning (sharing, collaboration, imaginative play) - Links to Curriculum for Wales: Science & Technology AoLE; Mathematics & Numeracy AoLE; Health & Wellbeing AoLE.
Overall risk (refer to separate risk assessment)	Medium – acceptable with precautions.

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Other comments	The benefits of outdoor exploratory play outweigh the risks, provided safety checks and adult supervision are maintained.
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Activity	Hazard	Risk	Likelihood (1–5)	Severity (1–5)	Benefit	Action to remove/reduce risk	Who?	When?	Risk Level
Mud kitchen play (soil, water, utensils)	Slipping on spilled water/mud	Child may slip and fall, causing minor injury	3	2	Sensory play, exploring materials, science, and math's learning	Ensure area is non-slip, clear water promptly, supervise closely	Staff	Ongoing	6 (medium – acceptable with precautions)
Mud kitchen (utensils)	Use of metal pans/utensils	Potential for cuts or finger trapping	2	2	Fine motor skills, imaginative play	Use child-safe utensils, regular equipment checks	Staff	Ongoing	4 (low – acceptable)
Tyres (climbing, balancing)	Falling from tyres	Bruises, sprains	3	3	Gross motor development, balance, coordination	Limit height of stacked tyres, supervise use, soft ground surface	Staff	Ongoing	9 (medium – acceptable with precautions)
Log stools (seating, play)	Falling off logs, splinters	Minor bumps, scratches	2	2	Social interaction, role play, coordination	Smooth logs, sand down rough edges, supervise	Staff	Ongoing	4 (low – acceptable)
Gazebo/s and pit	Tripping on entrance,	Minor injuries, irritation	2	2	Social play, role play, imaginative	Clear entrance, cover sandpit when not in use	Staff	Ongoing	4 (low – acceptable)

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	sand in eyes				ve learning				
General outdoor environment	Contact with plants, insects	Allergic reactions, stings, scratches	2	3	Nature connection, exploration	Check plants safe, inform parents of allergens, provide first aid	Staff	Ongoing	6 (medium – acceptable with precautions)

For many years, outdoor settings have been recognized as exceptionally rich learning environments for children, offering ample opportunities for exploration, discovery, and a deeper connection to the natural world. The significance of outdoor learning, particularly in early childhood education, has gained widespread acknowledgment over time. This recognition can be traced back to early educational pioneers like Friedrich Froebel, who emphasized the importance of gardens and outdoor spaces as vital areas for play and holistic development (Bruce, 2021). Additionally, contemporary educational frameworks such as the Curriculum for Wales (Welsh Government, 2022) and the Early Years Foundation Stage (DfE, 2021) further underscore the critical role that outdoor experiences play in fostering young children's growth.

Children's experiences during outdoor play are inherently multisensory, engaging not just their physical bodies but also their minds in a dynamic, often unstructured manner, which is particularly conducive to the development of essential mathematical and scientific concepts (Bilton, 2010). The variety of stimuli found in outdoor environments encourages curiosity and innovation, allowing children to interact with the world in fluid and imaginative ways. This kind of active learning not only enhances their academic skills but also supports social development, helping them to build relationships and understand their surroundings in a meaningful context. Thus, outdoor learning is not just an adjunct to classroom education but a foundational aspect that enriches the learning journey of children.

This learning experience is made possible, in large part, by the dedicated adults who work in early childhood settings. These professionals do much more than merely provide supervision; they play a crucial and active role in fostering children's development by promoting conceptual knowledge and encouraging long-term, collaborative thinking. Through various techniques such as scaffolding, they effectively challenge children, helping them to build on their ideas and insights. This process not only enhances cognitive growth but also deepens their understanding of complex concepts. By creating a supportive environment that nurtures curiosity, these educators empower children to explore, ask questions, and engage in

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meaningful dialogue, which is essential for their overall development and success in future learning endeavors (Siraj-Blatchford et al., 2002). Their dedication and expertise are fundamental in shaping the foundational skills that children will carry with them as they progress through their educational journey.

This essay aims to critically assess how adults facilitate children's engagement with science and mathematics in outdoor environments by integrating various theoretical perspectives, research findings, and curriculum frameworks. It will delve into the pedagogical theories of prominent figures such as Piaget, Vygotsky, Bruner, Froebel, and the Reggio Emilia approach to education. These influential thinkers have contributed significantly to our understanding of how children learn and develop, particularly in natural settings, where the richness of the environment can enhance scientific inquiry and mathematical reasoning.

Additionally, the discussion will explore different methods that promote effective learning, including curiosity-driven exploration, which encourages children to ask questions and seek answers through hands-on experiences. The concept of affordances in the environment will also be examined, highlighting how certain aspects of outdoor spaces can support specific types of learning and exploration. Furthermore, the value of loose parts play will be emphasized, illustrating how providing children with varying materials fosters creativity, problem-solving skills, and collaborative play.

These strategies not only enrich the learning experience but also empower children to take an active role in their educational journey. By engaging with their surroundings, children develop a deeper understanding of the world around them, which can foster a lifelong love for science and mathematics. Ultimately, this exploration underscores the vital role that thoughtful adult guidance plays in cultivating an environment where young learners can thrive.

The constructivist philosophy of Jean Piaget emphasizes the value of experiential, active learning, as highlighted in his influential work from 1952. According to Piaget, children progress through distinct phases of cognitive development, gradually constructing their understanding of the world around them through interactions with their environment. This approach underscores the notion that children actively build their knowledge rather than passively absorbing information. For instance, outdoor play serves as a vital context for developing mathematical and scientific knowledge, as children experiment with various materials, test their theories, and observe the cause-and-effect relationships that emerge during their play activities.

A practical example of this can be seen in a mud kitchen, where children pour water between containers. This activity is directly related to Piaget's concept of

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conservation, which posits that the quantity of a substance remains constant even when its shape or arrangement changes. Such hands-on activities not only foster creativity and problem-solving skills but also enable children to grasp essential mathematical principles in a tangible way.

However, Piaget's theories have faced criticism, especially regarding his perceived underestimation of the role that adults play in the learning process. Donaldson (1978) argues that while individual exploration is crucial, it is equally important to recognize how adults can guide and facilitate children's learning experiences. In this regard, Vygotsky's work provides a valuable counterpoint by emphasizing the significance of social interactions in scaffolding understanding. Vygotsky's theories suggest that collaborative learning and guided interactions with knowledgeable others can enhance children's cognitive development, highlighting an area that Piaget's focus on individual discovery may overlook. This ongoing dialogue between the theories of Piaget and Vygotsky enriches our understanding of the complex nature of learning and development in children.

According to Lev Vygotsky's 1978 theory, social interaction, and cultural resources mediate learning. Children do better under the supervision of peers or adults than they do on their own, according to his theory of the Zone of Proximal Development (ZPD). Practitioners of outdoor learning assist kids by participating in their play, posing open-ended questions, or bringing in fresh materials. When a child rolls a tire, for example, an adult may enquire, "What happens if you push it harder?" Within the child's ZPD, this scaffolding promotes the investigation of force and motion.

Vygotsky's theories serve as the foundation for modern sustained shared thinking methods, in which adults and children engage in discussion to jointly generate knowledge (Siraj-Blatchford et al., 2002). These kinds of relationships are made possible by the unpredictable and varied nature of outdoor settings.

Discovery learning and the significance of presenting information in ways that children can access through enactive (doing), iconic (pictures), and symbolic (language) representation were highlighted by Jerome Bruner (1966). Enactive activities like lifting logs, pouring water, or balancing on stumps are common ways for children to start outdoor play. After that, practitioners urge children to employ iconic and symbolic forms, including drawing natural patterns or utilising mathematical terms like "bigger," "heavier," or "half." Bruner also emphasised the spiral curriculum, which revisits topics at progressively more complicated levels. This cyclical return to ideas is naturally supported by outdoor play.

The kindergarten movement's founder, Froebel, highlighted the importance of play with natural materials and gardening as a basis for education (Froebel, 1887/2013).

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His concept of "gifts" and "occupations" is in line with modern theories of loose parts play (Nicholson, 1971), in which objects with no set function (sticks, stones, tires) foster creativity, imagination, and problem-solving skills. Froebel's idea is quite like outdoor learning, which is a setting where play with natural and unrestricted resources is interwoven with scientific and mathematical inquiry.

The environment is seen as a "third teacher" in the Reggio Emilia method, which was created in post-war Italy (Edwards et al., 2012). Outdoor areas are purposefully planned to provide chances for investigation and learning. The key idea here is affordance (Gibson, 1979), or the opportunities for action that an environment provides. A group of stones allows for sorting, counting, and construction; a puddle allows for splashing, measuring, and studying reflections. In Reggio-inspired environments, adults act as co-learners by watching and recording children's research and offering questions that deepen understanding.

One of the most important methods for fostering mathematics and scientific thinking outside is loose parts play. According to Nicholson's (1971) idea, an environment's richness is directly correlated with the range of loose parts that are accessible. Children are encouraged to experiment with balance, weight, size, and force by using objects like tires, sticks, pebbles, and cloth. Rolling tires, for instance, introduce the ideas of motion, gravity, and friction. To provide support, practitioners model interest, ensure safety, and connect play to mathematical language ("Which tyre rolls furthest?").

According to research, kids who play with loose parts exhibit greater levels of creativity, problem-solving skills, and teamwork (Daly and Beloglovsky, 2015). These resources are curated by adults, who also make sure they offer a variety of affordances and help kids identify linkages and patterns.

According to Siraj-Blatchford et al. (2002), the good Provision of Pre-School Education (EPPE) initiative recognised persistent shared thinking as a characteristic of good pedagogy. In an outdoor setting, this could entail a practitioner asking a child, "What do you think will happen if we add more water?" as they are building a dam with sticks. Such discussion promotes testing, hypothesising, and prediction—all essential components of scientific investigation.

"You used three stones here and two more — how many altogether?" is an example of how adults' model mathematical thinking. According to research, children's numeracy outcomes improve when educators intentionally include mathematical language into relevant circumstances (Gifford, 2014).

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The key to encouraging kids' outdoor activity is observation. Practitioners watch children's interests and spot the emergence of mathematical and scientific thinking rather than controlling play. For example, observing a youngster filling and emptying a bucket repeatedly may reveal a developing capacity comprehension. Then, adults offer more tools (like as funnels and jugs) to continue their investigation. This is in line with the Curriculum for Wales' emphasis on formative assessment methods (Welsh Government, 2022), which allow practitioners to build on the experiences that children have had.

Adults play a pivotal role in encouraging children's natural curiosity by engaging them in thought-provoking questions and demonstrating a sense of wonder about the world around them. Harlen (2010) argues that scientific inquiry during early childhood should focus more on curiosity and discovery rather than solely on formal experiments that can limit exploration. The outdoor environment is particularly stimulating; for instance, discovering a worm beneath a piece of wood can ignite conversations about diverse habitats, the intricacies of life cycles, and the process of decomposition. By nurturing an environment where children feel empowered to pursue their own questions, practitioners help cultivate an inquiry-based culture that promotes critical thinking and exploration.

The involvement of adults in this process is essential; however, it is crucial to find a balance between offering guidance and allowing child-led exploration. Research indicates that when adult interventions are overly directive, they can inadvertently suppress the children's innate curiosity and drive (Wood, 2013). Therefore, practitioners must navigate this delicate balance, enabling children the freedom to experiment and take calculated risks while ensuring their safety. For example, conducting a risk assessment of various play materials, such as tires and logs, is essential to make informed decisions about their use.

According to Sandseter (2009), engaging in "risky play" is vital for developing children's creativity and their ability to navigate challenges while interacting with concepts such as force, height, and speed. By allowing children to partake in these adventurous experiences, adults can help them build resilience and self-confidence in their abilities to explore the world around them. Thus, fostering an environment rich in curiosity and discovery not only enhances children's understanding of scientific concepts but also contributes to their overall development and well-being.

Adult participation is essential, but it must strike a balance between providing direction and honouring child-led play. According to research, adult interventions that are too directive may stifle natural curiosity and drive (Wood, 2013). Practitioners need to find a balance between giving kids the flexibility to try new things and take calculated risks while still guaranteeing safety (e.g., risk assessment of tires and

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logs). According to Sandseter (2009), "risky play" is crucial for fostering creativity and risk-taking abilities as well as for interacting with ideas of force, height, and speed.

Children can experience scientific ideas in tangible ways in outdoor settings:

- Material properties: according to Siraj-Blatchford and MacLeod-Brudenell (2020), combining earth and water in a mud kitchen exhibits both reversible and irreversible changes.
- Motion and forces: momentum, friction, and gravity are introduced by rolling tires or sliding items.
- Ecology and life cycles: studying plants and insects helps us comprehend environments, growth, and change (Worth and Grollman, 2003).

In outdoor settings, mathematical learning naturally arises:

- Comparing and measuring pouring water into various containers helps people learn volume and capacity (Gifford, 2014).
- Shape and space: Geometry and spatial reasoning are used while constructing dens or organising logs.
- Pattern and number: gathering stones or leaves offers chances for counting, sorting, and sequencing.

By giving names to ideas, posing leading questions, and relating play to past knowledge, adults enhance these experiences. For instance, a practitioner might enquire, "Which is longest?" after kids have measured sticks. How are you aware of this? This combines real-world gaming with mathematical reasoning.

Children have unmatched opportunity to interact with mathematics and scientific ideas in outdoor settings. To turn these experiences from play into worthwhile learning, adults play a crucial role. Based on the theories of Piaget, Vygotsky, Bruner, Froebel, and Reggio Emilia, practitioners create environments full of affordances, scaffold children's discovery, and extend ideas through prolonged shared thinking.

According to various research studies, children's comprehension of science and mathematics significantly improves when adults engage with them through meaningful conversation, careful observation, and the provision of thoughtfully selected resources (Siraj-Blatchford et al., 2002; Gifford, 2014). It is crucial, however, for adults to strike a delicate balance between offering support and allowing children the freedom to lead their own play experiences. This approach not only nurtures curiosity but also encourages a spirit of discovery.

In essence, outdoor spaces transcend the role of mere playgrounds; they serve as dynamic laboratories and workshops where children can explore their interests,

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formulate hypotheses, and tackle real-world problems. These environments become vibrant settings that encourage and enhance mathematical and scientific thinking. Under the thoughtful guidance of adults, outdoor areas lay a strong foundation for lifelong learning, instilling in children a sense of wonder and a desire to investigate the world around them. By recognizing and cultivating this balance between guidance and independence, adults can create rich learning experiences that resonate throughout a child's educational journey.

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