

AWE AND WONDER: SCIENCE, MATHEMATICS AND THE OUTDOORS.

***USING AN OUTDOOR ENVIRONMENT TO PROMOTE AND SUPPORT
CHILDREN'S SCIENTIFIC AND MATHEMATICAL THINKING.***

The pictures show the garden used in a homebased childminding setting, from two different angles.



(Bergelin, 2021)



(Bergelin, 2021)

Feature 1. Flora, fauna and life cycles.

The children who play in this garden, are surrounded by living things and can directly experience nature and are free to investigate. There are flowers, shrubs, herbs and fruit trees and the grass is real. There is a fishpond with a waterfall. There is a birdfeeder frequented by birds and squirrels. The children develop an affinity with life in the garden. They begin to understand the weather, seasons and life cycles. Together, we plant bulbs and seeds, nurture them and watch them grow. Children learn mathematical concepts by looking at the different seeds, comparing the shapes, colours and sizes. This leads onto measuring the size of the planting patch, how much space will we need for each plant to grow successfully? What size pot should we use first? These activities link with the initial progression steps of the Curriculum for Wales within Numeracy and the number system, relating to using language to compare, estimate and measure (Hwb, 2020).



(Bergelin, 2021). This picture illustrates how a small area can be used for children to grow lettuce, strawberries, and flowers. Engagement with this process helps them understand life cycles and connects them with living things.

The children have collected seeds from sunflowers they have planted and plant them again the following year, this gives an understanding of the concept of life cycles. This links in with the Curriculum progression steps in science enabling children to learn about the world around them and understanding about living things and growth (Hwb, 2020). By having the time to explore and play in the garden, the children discover and come across various creatures. There is an abundance of animal life throughout the year, enabling discussion about why they are there, how they survive in the outdoors, what they might eat and where they sleep. These type of experiences and conversations spark curiosity and interest, and help the children maintain their sense of wonder and care for their environment.

Feature 2. The Mud Kitchen – creativity and experimentation.

The mud kitchen helps to provide a link between indoor play and the outdoors. It is an extension of the toy kitchen, but outside it has increased scope for involvement, creativity, and experiments. The concoctions and potions that the children can create are not limited to mud, they can use grass, leaves, herbs, fruit and petals. They can mix things in pots, cups, baking trays and saucepans. Utensils can come from the kitchen, the garden shed or nature.



(Bergelin, 2021). This picture shows the mud kitchen and accessories. The kitchen is next to the raised bed where the children can source soil for their concoction's.

Our mud kitchen has a water container with a tap, so the children have control over filling the bowl and other containers. They can collect more water from the garden tap in the old kettle or a jug. They collect the soil from the raised bed next to the kitchen. Experimentation comes in the form of exploring the consistency of the mud and how it can change depending on the quantity of soil and water. This links into the Curriculum for Wales in a scientific way, exploring textures and properties, make decisions and choices about quantities (Hwb, 2020).

Children will play at creating 'food' and 'drinks' so soup and tea will be runnier than cake mix or mudpies. They will develop motor skills and hand eye coordination with the scooping, digging, pouring, carrying, mixing and serving. In relation to mathematics, they will be beginning to understand the concepts of weight, volume, and size. Filling a kettle with water makes it heavier than when it is empty, how can we carry it back to the mud kitchen? This is problem solving, two hands to carry instead of one. Or maybe some help from a friend. They also practice gross motor skills as they manoeuvre up and down the steps with empty and full containers.

Feature 3 – Water table and patio area – properties of water and force.

The patio area of the garden provides a space for the water table. It also provides the children with the opportunity to observe the pond and waterfall. The water table is the ideal height for babies who are just starting to pull themselves up and cruise around to hold onto and feel and splash the water. By doing this they hold on with one hand and bravely splash the water with the other, making cause and effect connections. Toddlers love to play at the water table and will spend time repeating actions, pouring water from one container to another, into the mini watermill, over their hands and arms and water the plants.



(Bergelin, 2021). In this illustration the children are playing with the watermill. By pouring the water in the top they have discovered that it makes the wheels spin, and splash, introducing the concept of water as an energy force.

Through conversation and discussion about what they are doing, children learn scientific and mathematical vocabulary. Words such as full, empty, floating, sinking, heavy and light introduce them to these concepts in an experiential way as they pour, tip and manoeuvre during their play, linking with curriculum progression steps (Hwb, 2020). In the winter months the water sometimes freezes, and children see water as a solid instead of a liquid. Added to the water table are accessories such as funnels, pieces of hose and sieves and measuring jugs. These items allow the children to experiment with different methods of transporting water and seeing how it moves through different shapes. They are also introduced to the concept of gravity and water as a force. Additionally, when filling the water table from the hose on a sunny day it creates a rainbow, invoking fascination with the 'magical' concept of light refraction and the fact that we do not necessarily need rain to make a rainbow, just water and light.

Risk Benefit Assessment

Location / Activity:	Homebased childminder setting, garden	Date:	17 September 2021
Assessor:	Elizabeth Bergelin	Review date:	26 September 2021

ACTIVITY	How will young people BENEFIT from this activity?	Possible hazards	Who is at risk?	PRECAUTIONS in place to reduce the risk of injury	Overall risk RATING: L/M/H
General use of the garden, exploring the varied environment. Navigating the different levels.	Children benefit from being outside and enjoy the added freedom it gives them to explore. Children become aware of their bodies and develop in confidence through movement. This benefits vestibular and proprioception development. Children benefit from climbing the steps and understanding different perspectives. Development of gross and fine motor skills. Fresh air and room to move. Experiencing the weather Sensory experiences of weather and nature, increasing curiosity. Children become aware of living things.	Weather: sunshine, heat, cold and rain. Children could become too cold or become too hot. This can cause illness or distress, hypothermia or hyperthermia. Falling or tripping could result in injury. Slipping on ice or wet surfaces. Branches and thorns. Animal excrement, birds and cats.	Child and adult	Appropriate clothing and sunscreen. Stay out of sun during high U.V. times especially in the summer between 11am and 3pm, always keep babies in the shade. Observe weather forecast and U.V. forecast. Supervision for very small children negotiating steps. Wrap up warm in cold weather, wear waterproofs and wellington boots to avoid becoming too wet and too cold. Grit on slippery surfaces in icy conditions. Foam mats to be placed under the slide when on the concrete patio. Remove low and loose branches before going out with the children. Check for and remove animal excrement.	M - H

ACTIVITY	How will young people BENEFIT from this activity?	Possible hazards	Who is at risk?	PRECAUTIONS in place to reduce the risk of injury	Overall risk RATING: L/M/H
Gardening, digging, planting, watering and harvesting.	Children will benefit from this activity by learning about lifecycles, plant growth and care. They will develop an understanding of where food comes from and the appreciation of plant life and its benefits to other creatures as well as people. Children will discover the other creatures that live in the garden such as insects, spiders, birds and squirrels.	Tools to be used must be in a good condition and age appropriate. Plants, bulbs and seeds must not be hazardous to touch or ingest. Stings from insects and plants and bites from insects. Berries and buds that are not edible.	Everyone	Adequate supervision during the activity and discussion beforehand to lay out the rules. The supervising adult should demonstrate correct use of tools and assist when requested. Children wear gardening gloves when digging and handling plants to prevent infection to existing cuts. First aid person with correct training and equipment to hand. Knowledge and record of children with allergies. Teach children not to eat anything from the garden unless they check with an adult first.	M

ACTIVITY	How will young people BENEFIT from this activity?	Possible hazards	Who is at risk?	PRECAUTIONS in place to reduce the risk of injury	Overall risk RATING: L/M/H
Mud kitchen	Being able to experiment and explore the water, soil and other elements from the garden, mixing to create different textures and consistencies. Imagination and creativity, along with exploration and discovery. Development of motor skills and sensory development when digging, carrying, mixing and pouring. Supports schemas such as transporting, trajectory,	Ingestion of mud or contaminated water. Splashing water or mud in eyes. Getting wet and then too cold.	Everyone	Warn the children of the hazards of tasting the mud and water, rule that it is not to be consumed. Understand the rules about hygiene and washing hands after play to remove germs and bacteria. First aid person and kit equipped with an eye bath. Provision of aprons or waterproofs to keep clothes dry.	

Water Table	Here the children can play with the water and accessories. There are opportunities for pouring, splashing, floating and sinking. They will begin to learn about the different properties of water, warm, cold, ice. Bubbles and food colouring or paints can be added for additional experiences. There are watermills attached to the table, so children begin to understand the concept as water as a force.	Ingestion of water from the table which could be contaminated. Children could get very wet and cold due to splashing. Risk of drowning.	Everyone	Rule in place not to drink the water, children made aware that this is not drinking water. Constant adult supervision due to the depth of water and age of the children. Put children in waterproofs or waterproof aprons to avoid them getting too wet and cold. A change of clothes if necessary. Check the water for contaminants, such as insects, before the children play.	M - H
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The adult role in supporting and encouraging children to have opportunities to engage in science and mathematical concepts in the outdoor space such as the one in the photograph.

According to Grigg and Lewis (2016), early 18th century philosophers such as Rousseau and Pestalozzi, were pioneers in the belief that children should have a connection with nature and be able to learn through real life experiences. Indeed, the founder of the 'kindergarten', Friedrich Froebel, was influenced by these ideals as he developed his approach to early education. Many of these principles, including learning in the outdoors, are embedded in practice today (Tovey, 2017). Froebel recognised children as powerful learners, full of curiosity and this links with Piaget's theory that children play an active role in their own learning process (Gray and MacBlain, 2015).

The outdoor space featured in this portfolio is part of a homebased childcare setting and allows children the freedom to move inside and outside. Having the garden provides additional scope for play and exploration, and it also helps children build confidence to explore. White (2011) discusses Piaget's description of infancy and early childhood as a time when children are making sense of their environment through investigation and developing their motor sensory range using movement and exploration. Practitioners have a responsibility to recognise that being allowed to experience the outdoors is vital for movement and sensory development, the features in this garden provide these opportunities. Different children will have had different experiences of the outdoors, so by providing a relaxed open-door practice gives them the time to adapt and get used to being allowed outside to play (Bilton and Crooke, 2016).

The Enabling Pathways document (Welsh Government, 2021) outlines the three main resources for the curriculum as the environment, the experience and the adult. Adults are responsible for creating safe environments and enriching experiences as well as planning, designing and implementing the curriculum. Ryder Richardson (2013) states that adults providing outdoor learning need to have the knowledge and enthusiasm to make the experience meaningful and worthwhile. However, it is also important that the children feel comfortable so they can be fully engaged. An awareness of Maslow's

hierarchy of needs and how to fulfil those needs is an essential skill for any practitioner. A child cannot learn if he is hungry, tired, afraid or lacks confidence (How Young Children Learn, no date). Practitioners need to build relationships and connections to engage the child, to make them feel safe and secure to reduce their stress levels which will in turn enhance their learning capacity.

Regarding safety and security, practitioners must provide an environment that is challenging but not hazardous (Play Safety Forum, 2014). The garden in this portfolio is used by children of various ages from birth up to 11 years old. Weighing up the risks and benefits is an essential role for the adult. But protecting children from harm is just as important as having a good understanding of physical and sensory development. Children need to be able to move and explore freely to develop their muscles and core body senses. For example, babies need to develop their sense of proprioception, a sense of themselves and their capabilities. These essential stages of development not only help with coordination, balance and strength, but also enable children to self-regulate and develop independence and confidence (Greenland, 2021).

It is recognised that adults must support learners to become independent and resilient, and this can be achieved through challenging and risky play (Welsh Government, 2021). As Gibson, Cornell and Gill (2017) point out, the ability to take risks increase children's competency in their own risk perception and management. Trusting children to work things out for themselves can promote a natural learning impulse (Gill, no date) and the Health and Safety executive (2012) also recognise the benefit and importance of risky play for children and how good it is for their well being and development. Many Scandinavian pedagogies have embraced outdoor play for enhanced learning within kindergartens (Mosser and Martinsen, 2010). Carefully weighing up the risks and benefits and giving children the freedom and trust to explore the outdoors, has seen results such as less stress, better concentration and improved motor skills (Roberts and DeJong, 2016).

Educational approaches and theories emphasise the crucial role the adult plays in providing rich environments and experiences. Piaget stresses that the provision of a rich environment will enhance development and the Montessori methods advocate for good organisation and planning (Gray and MacBlain, 2015). Of course, it is the adults

who set up and create the learning environment, so they need to understand how it effects learning and play for the children. McInnes *et al*, 2013) point out that it is the responsibility of the adults to create enabling environments where children can perceive their activities as play to support their learning and development. Indeed, Donaldson (2015), states that teachers must have a good understanding of how to work with children to enable them to reach their potential.

It is recognised that just being outside is not enough, the adults need to ensure that the children are having meaningful experiences. Practitioners need to have the resources, knowledge and confidence to provide mathematical and scientific learning experiences (Robertson, 2017). There is provision for practitioners to access outdoor learning or forest school training to help them provide an enriching and worthwhile experience for the children (Jozwiak, 2021, p.46). However, while it is known that playing outside is a vital part of healthy child development, the provision of outdoor learning and teaching is yet to become common place in line with a decline in outdoor play for children (Waller *et al.*, 2010). One of the barriers is accessing the training to equip practitioners with the skills and confidence to provide learning in the outdoors, it is only recently that more universities and colleges are including outdoor modules as standard on their courses (Dietze and Butler, 2020).

Children are innately inquisitive about their surroundings, therefore being outside in nature gives the opportunity for the learning of mathematical and scientific concepts to develop through play-led activities (Cohen and Waite-Stupiansky, 2020). The Foundation Phase (Welsh Government, 2018) lends itself to this way of learning, by being play-based, experiential and child led with the adult placed as the facilitator, supporting the child to promote confidence and curiosity. Dewey believed that children learn best with interaction and support, being able to ask questions to make sense of situations and concepts (Gray and MacBlain, 2015). Furthermore, Vygotsky's Zone of Development highlights how adults as the 'more knowledgeable other' can realise the potential within the child and extend their learning further than might be possible if left to play alone (Tassoni, Bulman and Beith, 2008). As Froebel believed, adults can nurture a child's learning by applying their knowledge of child development and being sensitive to the individual needs of each child (Tovey, 2017).

Applying science and mathematical learning to the outside classroom does not require practitioners to have high level qualifications in these subjects, but they do need to have a sound understanding of learning theories. Developing science and mathematical concepts during the early years is the ideal time to take advantage of this natural curiosity in children (Beery and Jorgenson, 2018). However, research suggests that many early years practitioners have negative experiences of science and lack confidence in their own mathematical knowledge (Tinney *et al.* 2020). It is important to remember that early year's education is about introducing the understanding of the science and mathematical concepts. Introducing language during everyday activities and routines in the outside environment provides endless scope for this. To become successful learners in line with the new Curriculum for Wales (Hwb, 2020), teaching children how to question and think out loud and think critically about what they are doing will develop their metacognitive abilities. Metacognition is associated with increased learning ability and adults can help children develop this and realise their potential (Neaum, 2019)

A key approach to developing science and mathematical learning in the outdoors, is to utilise Sustained Shared Thinking. A high involvement of interaction between staff and children enhances progress. Adults and children can work together to solve problems, clarify concepts, evaluate activity and extend the narrative (Neaum, 2019). Piaget recognised that the early years are a vital time for children to develop their language skills, to enable them to make links between activities, concepts, thinking and communication therefore developing cognition (Neaum, 2019). The Reggio Emilia approach emphasises the link between the 100 languages of children, Loris Malaguzzi believed in the benefits of communication and conversation with children to encourage independent thinking (Pound, 2020).

Science is essentially a quest for knowledge through exploration and experimentation and planting a seed is like an experiment (Cohen and Waite-Stupiansky, 2020). When taking part in gardening activities a child does not really know exactly what will happen to their seed or when, so it is a learning journey. It is the role of the adult to maintain the enthusiasm and interest of the child in this process. To make it interesting, rewarding and exciting. Mathematical concepts such as estimation, counting and measuring will also come into play with the selection of the correct size pots, the right

amount of soil. How many seeds are there, how much water? How much time will it take to grow the plants, how tall will they get? How can they be identified? These are discussions that can be enhanced by the adult and tie in with sustained shared thinking.

Having the garden allows daily access for the child to build on their knowledge and experiences. White (2011) discusses the constructivist theory and how rich interactions with the setting and between peers and adults, helps children to revisit and grow their learning. Bruner's theory of the spiral curriculum, revisiting topics and growing in depth and complexity, sits well with the outdoor learning environment (Gibbs, 2014). The connections that children make with nature and the seasons, through play, activities, and engagement with others develop their cognition and helps to extend their thinking (Gray and MacBlain, 2015). Adults providing these regular experiences and giving children the time to enjoy, and play helps them make full use of the resources and allows them time to assimilate and process the information (Ryder Richardson, 2013).

Adults play an important role in providing resources for children to play with. Nicholson (1971) came up with the theory of loose parts. This means that children could play more inventively with parts as opposed to task specific toys, 'parts' being items that children can apply their imagination to and play with how they want to. For example, a plastic pipe can be a telescope or a tunnel, a stick can be a wand or a hammer. Kingston-Hughes (2021), discusses how children being able to adapt and use items in imaginative ways, provides more valuable experiences in terms of creativity and learning. While there is not a huge amount of space within the garden in this portfolio, there are some loose parts that children can play with. There are pipes, a milk crate, cardboard boxes, and recycled containers. Children are also able to bring in sticks items they might find outside of the setting.

The Froebel approach also recognises the value in providing children with the opportunity to use their imaginations in play. This can help with mathematical development and symbolic thinking (Tovey, no date). Playing with open ended materials or loose parts can help children develop scientific problem-solving skills, promoting divergent thinking. Gibson, Cornell and Gill (2017) state how the

unstructured child led nature of loose parts play promotes engagement and creativity. The affordance given to random objects drives children's imagination and provides challenging and rewarding play. Within the garden setting, the combination of the mud kitchen, the raised bed and the loose parts provides the children with scope for different types of play. For example, the mud kitchen is not always a kitchen, it could be a work bench or a science laboratory.

While Vygotsky did not attribute set ages to child development, he did suggest that experiences and events in the first 2 years of life could have an influence on a child's future learning (Gray and MacBlain, 2015). Believing that children are born learners, Vygotsky's theory validates the necessity for infants to have the opportunity to experience rich environments, including the outdoors. By providing engaging activities such as the water table and the mud kitchen, young children are given the opportunity to play and explore while their senses are stimulated, experiencing the flux of temperature, light, sounds, and smells of outdoor life.

Adults can provide activities that help children to explore sensory play and support schemas. Piaget's theory on schemas was that children use them to help them make sense of information and the world around them (Gray and MacBlain, 2015). Schemas can reflect children's learning patterns, and by paying close attention, through observation and conversation, the adult can promote and enhance these methods for the child (Athey, 2007). Many schemas can be covered in water play as shown in the water table feature. For example, the trajectory schema can be supported with pouring and running water. Watermills, guttering and tubes that children can use will enable them to explore these concepts. The enveloping and containing schemas are also possible to explore by pouring water between different containers (Neuam, 2019).

In the garden featured in this portfolio the mud kitchen is positioned next to the raised bed. This enables children to access the soil they need for concocting their muddy mixtures. In the section where they can dig and play, the transporting schema can also be supported. By providing spades, buckets, trucks and diggers the adult will support the child's ability to explore different methods of transportation (Martin, 2019). Collecting and moving the soil from the source to the kitchen can be helped by providing containers, boxes, recycled food tubs, cake tins and spoons. Adults can

enhance this type of play by modelling behaviour and introducing language in conversation to further development and understanding. Using positional words such as in, on, full, empty and overflowing help children to develop this type of schema and make sense of it (Louis and Featherstone, 2008).

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