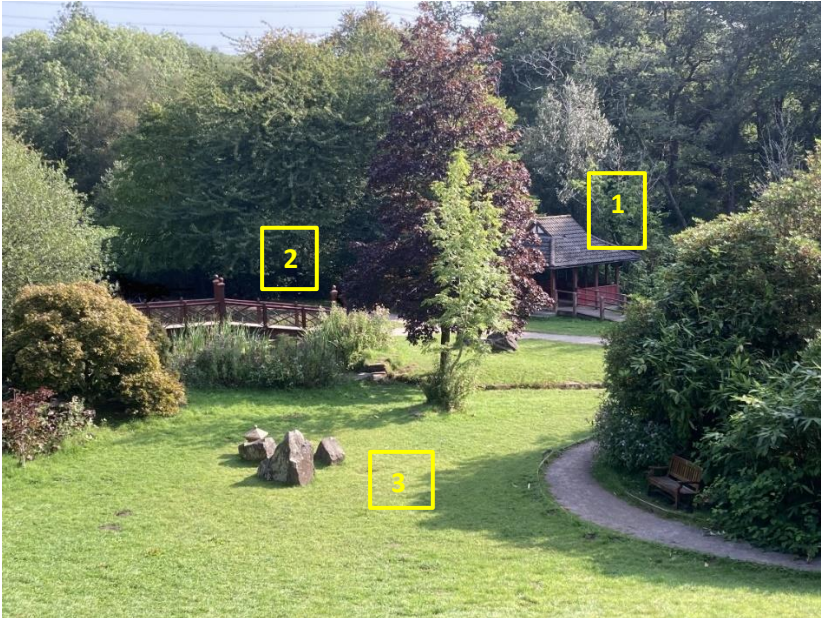


Using An Outdoor Environment to Promote and Support Children's Scientific / Mathematical Thinking.

Section 1



Source: Davies, 2021

Section 2

Listed below are some of the learning opportunities and vocabulary taken from the National Literacy and Numeracy Framework (Welsh Government, 2021) and the Curriculum for Wales (Welsh Government, 2020) that the children can experience but there are no limits to what they may discover through using their curiosity and imagination.

Learning possibilities: observing, estimating, weighing, counting, listening, comparing, using gross and fine motor skills, spatial awareness.

Vocabulary: light, dark, reflection, longer, shorter, louder, quieter, higher, lower, same as, different, faster, slower, gravity, energy, wider, narrower, full, enough, more, less, least, thicker, better, worse, placement prepositions, force, smooth, rough, deep, shallow, half, group, sort, holds more/less, hot/cold, how many? right, left, up, down.

Feature 1: The Pagoda



Source: Davies, 2021

- Experimentation with shadows and dispersion of light using artificial and natural sources. Using different coloured translucent Perspex sheets or opaque paper and placing objects or paper puppets behind then shining the light through it or placing shapes on paper and shining the light at different angles. The shadows can also be drawn around. Experimenting by combining different shapes gives opportunities to discuss any differences in natural and artificial light. Experiment with creating longer or shorter shadows depending on where the light originates.
- Sound experiments. Dropping objects from different heights, listening for the differences in sound and echoes and timing how long it takes to hit the floor. Using musical instruments listening for tones and comparing the sounds made inside the building and outside.
- Using the ramp to roll various objects and make decisions on the most effective shape by observing how smooth and fast they travel.

Feature 2: Bridge and waterfall



Source: Davies, 2021

- Mixing soil and water to create mud paintings or sculptures. Varying the amount of soil and mud to create different consistencies will provide opportunities to experiment with combining materials.
- Creating an underwater magnifying glass using cling film and an open-ended tube will allow children to investigate the wildlife in the pond. There is a ramp into the pond with shallow water so they could do this directly or collect a sample in buckets. They can make observations on the shapes and symmetry of the insects and bugs collected. Placing various natural objects in a jar filled with water magnifies the object but this activity can also be used to show displacement of water and the effect that placing something in water has on the level of liquid in the jar. They can mark the different levels and measure the difference. Children can create jar art by combining different natural objects and adding small stones.
- Observing forces in action by dropping objects from the bridge to observe the splash made. Comparing the weight of the objects prior to dropping them can provide links to weight and surface area and the amount of splash made. Providing nets will allow the children to fish the objects from the water thus encouraging collaboration and working together.
- Children can collect sticks and use them for a variety of mathematical concepts. Providing rope or string they can create 2D and 3D shapes. They can order them according to size and count them. They can create stick pictures or objects or drop them near to the small waterfall to observe the difference in speed before and after.
- Paper and crayons will provide opportunities to do rubbings on the bridge, path and jetties to observe different patterns.

Feature 3: Inclined grass area and rocks



Source: Davies, 2021

- Rolling bike tyres and hoops to demonstrate gravity and friction and timing how long each of them takes to reach the bottom. They can use stop watches or just count, estimating beforehand how long they might take. They can run or roll down to see if they can beat the tyres and hoops then compare this by carrying out the same activity on the gravel path to the side or over the bridge at the bottom of the slope. They will be experiencing phenomena such as kinetic energy, gravitational potential, and momentum.



Source: Davies, 2021

- The rocks and stone lantern on the side of the slope allow for climbing and experiencing the feel of different surfaces. They can investigate the properties of the objects using magnifying equipment and taking rubbings. Provision of loose parts such as planks of wood or material will encourage the children to use the rocks for other purposes such as supports for a den or walkway. Measuring the rocks using different techniques such as lengths of rope, string or by joining hands around the object and comparing these measurements with other objects in the area encourages them to estimate by comparison.



Source: Davies, 2021

- There are trees everywhere, but two areas either side of the slope lend themselves to investigation, curiosity, and imagination. As can be seen in the photographs above the children are able to access the centre of the areas and providing loose parts such as material, planks of wood, barrels, and tyres will give them the opportunity to create a secret area.
- Collecting leaves and estimating how many are in each jar before taking them out and counting them. Strategies such as grouping large numbers of an item into groups of ten for instance, will help with accuracy in counting. Children can collect items using a bucket or basket, but they can also create a nature bracelet. Wrap a length of masking tape around their wrist and they can pick up and stick the items onto the bracelet. This can form a memory of their adventure to be revisited later as a record of their visit.

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- To experience static electricity, rubbing a balloon against manmade material allows them to pick up leaves and other natural material. They can compare the results by rubbing the balloon on the grass or other areas to see the difference. The children will love doing this with their hair.
- The Woodland Trust (1972) produce swatch books that children can use to identify the things they collect and observe, as well as playing detective if they find a poo! The children will begin to appreciate the world around them and understand that not all nature is human. It will improve their listening and observational skills and can form the basis of practicing mindfulness.



Source: Woodland trust, (1972)

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The following tables display the links between the activities in each area and the Curriculum for Wales descriptions of learning (Welsh Government, 2020).

Science and Technology	Shadow Play	Sound	Ramp	Mud	Magnifying glass	Dropping	Sticks	Rubbings	Construct	Collect	Balloon	Identify	Incline	Rock
Being curious and searching for answers is essential to understanding and predicting phenomena.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Design thinking and engineering offer technical and creative	X	X	X	X	X	X	X	X	X		X	X	X	X
The world around us is full of living things which depend on each other for survival				X	X		X	X	X	X		X		X
Matter and the way it behaves defines our universe and shapes our lives	X	X	X	X	X	X	X	X	X		X		X	X
Forces and energy provide a foundation for understanding our universe	X	X	X		X	X	X		X		X		X	X
Computation is the foundation for our digital world.	X				X		X		X		X	X		
Mathematics and Technology	Shadow Play	Sound	Ramp	Mud	Magnifying glass	Dropping	Sticks	Rubbings	Construct	Collect	Balloon	Identify	Incline	Rock
The number system is used to represent and compare relationships between numbers and quantities	X	X	X		X	X	X		X	X		X	X	
Algebra uses symbol systems to express the structure of mathematical relationships														
Geometry focuses on relationships involving shape, space and position, and measurement focuses on quantifying phenomena in the physical world	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Statistics represent data, probability models chance, and both support informed inferences and decisions	X	X	X	X	X	X	X		X	X	X		X	X

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RISK BENEFIT ASSESSMENT

Location / Activity:	Woodland and Park	Date:	15 th September 2021
Assessor:	Michele Davies	Review date:	15 th April 2021

The boxes in the table below will expand as you type into them; pre-entered text is simply for illustration. You should delete irrelevant items and replace with text relevant to your circumstances.

Your overall risk rating – Low, medium or high – is based on your judgement about whether the BENEFITS of the activity or opportunity outweigh the RISKS.

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
Bridge and Pond area	- Experiencing the properties of different materials and matter. - Understanding there are other life forms in nature that are non-human. - The physicality of walking on different surfaces and wading in water. - Gross motor skills through throwing objects into the water and using the net to retrieve them. - Experiencing the feeling of height and suspension whilst on the bridge.	- Falling from the bridge into the water - Drowning in the pond - Insect bites. - Falling or tripping over changes in surfaces. - Falling into the water.	Children and adults	- Explain the rules of playing around water to the children prior to the trip and ensure understanding through role play. - Ensure they are familiar with the area by showing them photographs. - Have sufficient staff within the area to observe the safety of the children and limit the number of children carrying out activities in the area at any one time. - Ensure children are wearing appropriate clothing for activities near water.	L

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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
Pagoda	• Experimenting with sound and comparing the differences in tone inside and outside of the structure. • Experiencing forces through bouncing balls of different size and weight. • Understanding properties of natural and artificial light. • Studying the properties and applications of differently shaped objects and their movement. • Gross motor skills and visual perception from using the steps	• Cuts and grazes from falling on the ramp, steps or from the benches. • Inappropriate use of the resources for creating the shadow experiments resulting in injuries. • Splinters from the wooden structure.	Adults and children	• Prior to the visit, facilitate activities to enable children to practice running and walking on a variety of surfaces. Provide opportunities for children to practice balancing to improve vestibule movement. • Prior to the visit ensure the children are aware of how to use safety scissors and be familiar with cutting shapes using a variety of sources. • Carry out checks of the area before the children arrive at the area and remove any potential hazards that might cause injuries.	L

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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
Grass Incline and Wooded area (570)	• Discovering forces by rolling objects, and themselves down the incline and experiencing resistance when attempting to roll objects up the incline. • Experiencing life cycles by investigating the wooded area. • Risk taking when using loose parts and climbing on the rocks. • Becoming familiar with estimating time, distance, and size as well as measurement using loose parts instead of conventional means. • Improving gross motor skills and practicing controlling their body movements. Advancing their proprioception sense.	• Bumping into each other when rolling down the hill. • Falling from the rocks. • Injuries from branches, brambles, and nettles. • Wandering off on their own and becoming lost.	Children and adults	• Roll the tyres down the slope first helping the children to make observations on the trajectory of the tyres and the connection between how close the tyres were before starting. Use this information to allow them to make deductions on how they need to conduct the activity when they take part. • Practice balancing activities to strengthen their vestibule movement including moving over uneven ground and negotiating pebbles/rocks. • Read books that contain adventures in the jungle or woods and emphasise how the characters in the book negotiate moving through dense undergrowth. • Golden rules. Explain to the children that they need to remain in the designated area and ensure they are aware of where that is. Prior to the visit, explain what they must do if they are lost and ensure there are sufficient staff to supervise the safety of the children.	L

Section 4

Campbell and Speldewinde (2020) suggest that scientific skills are attained when children become “.... independent observers of everyday objects, materials and living things” and a combination of affordances, the environment and sympathetic adult support will encourage abilities that will result in scientific learning. To create future mathematicians, there is a necessity for facilitation of an appropriate environment by the practitioner for the enablement of making connections and providing first-hand, naturally occurring problem solving situations that will fulfil a child’s innate ability to question everything and satisfy their curiosity (Tucker, 2014).

There is a responsibility on the practitioner to ensure that children do not just learn facts but absorb knowledge through rich experiences that will enable them to make links between the six areas of learning and apply this to situations in the real world (Welsh Government, 2020). Practitioners need to be learners as well as educators so that they can provide the most beneficial experiences for children to develop holistically and be in control of their own learning (Welsh Government, 2018). Froebel (Tovey, 2017) emphasized the importance of practitioners who were knowledgeable and well-qualified as well as being in tune with nature. Lack of confidence to engage with children in these areas by Early Years Educators becomes a barrier to facilitating opportunities but professional learning can de-mystify pre-conceived fears of science and mathematics (Gealy *et al.* 2020) and result in more confident educators who can improve the way in which children experience science and mathematics phenomena (Danaia *et al.* 2020). Dewey saw educators as creators of opportunities and providers of holistic learning through social interaction, who needed to have more autonomy over the curriculum enabling a greater degree of reflection forming the basis of deeper understanding of concepts (Aubrey and Riley, 2019). The Curriculum for Wales (Welsh Government, 2020) set out the aims to develop the learner holistically through exposing them to meaningful learning experiences so that ultimately, they will become well-adjusted confident individuals who will reach their full potential and become proud and effective citizens through the four purposes (Welsh Government, 2015). The Curriculum puts emphasis on individual needs and promotes the partnership between learners, practitioners, the family, and the community working together to achieve the four purposes (Welsh Government, 2018).

Documentation of children’s activities allows practitioners to reflect, analyse and remember their actions and decisions (The Compass School, 2018). Both the Reggio Emilia and Te Wāriki approach ensure that children can view the results of their learning by displaying samples of their work so that they can progress their learning by reviewing the evidence. It shows respect for the efforts of the child and that they are capable learners and believe that natural rather than staged photographs or videos will catch the emotions of the moment and tell a story of how they achieved their goal. Practitioners and parents can gain insight into a child’s learning and make plans for future progression (Anthony, 2014). The difficulties with learning stories are that they are subjective in they rely on the confidence of the practitioner in their subject knowledge and

with no framework to work within, therefore some stories make strong links to dispositions whereas others are more narrative. This refers to a previous observation that the inclusion of professional learning can raise confidence. The Curriculum for Wales (Welsh Government, 2021) sees assessment as an integral part of teaching and learning and should form part of the classroom routine however, as with the Te Wāriki approach, the details of assessments are to be the responsibility and reflect the chosen curriculum of that school. Early Years Educators will no longer be required to carry out a base line assessment but assess abilities using an 'on entry assessment' and further assessments of a child's leaning progression will be based on abilities not on age. The Welsh Government intend to support practitioners with professional learning and are encouraging schools to move away from traditional 'tick list' assessments and to devise fair continuous assessments across the 6 areas of learning. Using learning stories, journals, portfolios, and recordings will enable practitioners to reflect on learning progress and plan for future activities to strengthen or introduce further skills (Anthony, 2014).

Observation, planning, and reflection, provide information of children's interests giving learning opportunities that will lead to prolonged engagement along with more effective one-to-one communication, which is fundamental to developing social skills and enhancing emotional advancement (Duglen 2015). Montessori believed that obtaining information in this way allows practitioners to choose an environment where children have the opportunity experiment with their senses (Aubrey and Riley, 2019) and allows for the facilitation of activities and resources that will give children the freedom to develop ideas supported by Froebel (Tovey, 2017). Sensory awareness, according to Piaget, was a necessity before advancing to the next stage of symbolic thinking where a child's fascination in and intrinsic ability to interact with their environment allowing the creation of schemas enabling them to understand the world around them and make sense their own actions (Aubrey and Riley, 2019). Children have an innate ability to perform schemas from birth and enable the necessary scientific and mathematical skills such as exploration and investigation that will become highly beneficial to their holistic development (Beswick *et al.* 2010). Encouraging these repetitive actions gives valuable information to practitioners so that they can optimise learning through the provision of appropriate resources and activities (PACEY, no date) and facilitate the appropriate environment that will encourage children to further develop established schemas and create new ones. (Beswick *et al.* 2010).

There should be no distinction between education and play and all areas of learning should naturally converge and cross reference (Nicholson, 1971). Objects randomly found in any environment can break the uniformity of an area created supposedly for children that is stark and uninviting and introducing or including loose parts leads to a sense of community and more social interaction. Observation of children in a classroom environment using loose parts that have previously been used in outdoor play or using them during non-play session shows how children adapt these resources to different situations (Casey and Robinson, 2019). They can be used as an introduction to skills prior to play sessions in different environments. In an article by Rahardjo (2019) the

use of loose parts supported learning in STEAM subjects and children can develop a wide range of mathematical competencies, observational, problem solving and inferential skills. They are high affordance objects that give children options on how best to utilise its function dependent on their ultimate objective. Bogunovich *et al.* (2019) discovered that fixed items as part of the environment or even a child's own body can afford opportunities for children's inquisitiveness, experimentation, and investigation. In this case, loose parts become affordances or vice versa. Using natural loose parts, art, or musical instruments, allows children to become more creative and open to using their imagination ultimately leading to deep thinking skills (Brandao and Theodotou 2020). Brunton and Thornton (2010) advocate the use of natural resources such as water and mud as well as open-ended resources like the shadow play, natural materials and loose parts included in the activities, to create the opportunities for scientific investigation.

Frederick Froebel (Tovey, 2017) saw outdoor play as giving children the freedom to make choices, gain independence and encourage determination by connecting with nature, allowing for investigation, experimentation, making links to past experiences and predicting future outcomes. Exposing children to the natural environment at an early age promotes positive future attitudes, values, and habits along with a respect for nature and a sense of responsibility and bringing an awareness of sustainability of resources (Oh, 2015). Children become curious through experiences that utilise all senses as well as being physically active and can bring an awareness of number sense and ordinality that have a positive effect on future success academically (Danaia, 2020). Taylor (2017) agrees that awareness of the natural world through first-hand experiences allows for a realisation of life cycles through understanding there are different eras in time and leads to an awareness of how natural resources are used indoors and their effects on the environment. Barrable (2016) extends this idea and talks of '*nature connectedness*' explaining that not only are there benefits to social and emotional development from being outdoors, but it contributes to children's future decisions and reinforces sustainability through Education for Sustainable Development. She also noted that understanding how we as humans exist within the natural world confirms these connections with non-humans and sees the emergence of empathy and the positive attitudes needed to sustain the natural environments for the future. Exposure to the outdoors alongside well-chosen resources and activities has far reaching effects on holistic development and embedding positive future habits. Learning Through Landscapes (2019) promotes STEM activities in the outdoors promoting early exposure to the practical side of traditionally class or laboratory-based subject, believing that this benefits the basic skills required to become future scientists or mathematicians, contributes to improved concentration skills, general wellbeing, and positive mental health.

Children should be allowed to make decisions on what is safe or unsafe according to Casey and Robertson (2019). They are more likely to benefit physically, emotionally, and socially through managing their own risk, building resilience and perseverance when not bounded by too many constraints and rules laid down by the practitioner. Botteril (2018) suggests that physicality is an important part of developing gross motor skills

and there is a need for practitioners to include aerobic activities in learning. This type of energy release is higher risk however Botteril (2018) agrees with Casey and Robertson and adds that children should have the freedom to self-assess their environment as part of the learning process. Gill (2007) however challenges the difficulty in measuring the benefits of risk taking in childhood but does suggest that children are born to take risks and that if this urge is not facilitated then they are likely to seek out challenges that may tip the risk/benefit balance. There is evidence to suggest that risk aversion can have adverse effects on situational assessments in adulthood, and a negative impact on the promotion of a healthy active lifestyle (Bienenstock *et al*, 2015), so he advocates a need to include risk taking in a child's learning within a controlled environment. In forest schools, experienced practitioners will know the capabilities, both physical and cognitively, of the children in their care and will provide an environment that reduces the hazards but still offers risks that will challenge the children's decision-making abilities (Blackwell, 2017).

Else and Sturrock's Colorado Paper (1998) discuss the play cycle and how sensitive interaction benefits both adults and children in the learning process. Through awareness of play cues and careful observation of the direction of play, adults can effectively encourage reflection by supporting the children within a particular framework. The practitioner may be given the opportunity to take part in medial or complex intervention, becoming part of the play and having an integral part in its direction at which point it would be appropriate to introduce sustained shared thinking so that the adult can support the progression of learning by extending ideas through open ended questioning and suggestions (Siraj-Blatchford, 2009). Sympathetic responses and prompts from the practitioner will encourage social interaction and engagement with the resources, focusing attention on the scientific and mathematic phenomena that is occurring (Craft *et al*, 2015). Bandura championed the role model, and opportunities to observe other children and adults interacting with the resources and environment, will encourage learning through copying, experimenting, or doing, as well as verbal interaction (Aubrey and Riley, 2019). Practitioners can use the Spiral of Discovery to encourage scientific learning and development (Brunton and Thornton, 2010). Its four stages call on the support of the practitioner when needed to facilitate the revisitation of exploring, asking questions, seeking understanding, reflecting, and evaluating in a cyclical format. To enable this, the adult needs to show enthusiasm, curiosity, and knowledge, to act as a role model and work together with the children in a sympathetic capacity. It allows children to investigate and to build on prior knowledge, mirroring Bruner's spiral curriculum (Aubrey and Riley, 2019). Casey and Robertson (2019) agree that practitioners should be aware of play cues and understand the necessity for freedom of exploration and investigation and as part of that freedom, time should never be a constraint nor interference in the direction of play regardless of the original intention of the activity. This reflects the basis of the play cycle, in that play should be facilitated not enforced. Adaptation of what is being observed in real time as opposed to what was expected will uncover an area of learning and a skill that will advance a child's development and during these observations, practitioners search for the deeper meaning to

a child's actions (Casey and Robertson, 2019). They should seek to fully understand why the child has chosen a particular resource, how they were using it and how the experience could be improved. Evaluation of the activities and observations are key to determining the effectiveness of learning and development, but this will only be useful if the mode of observation produces the optimum information (Casey and Robertson, 2019).

When designing or planning the areas for development, practitioners should provide the opportunities for affordances. The practitioners themselves can also become an affordance in the way they facilitate the learning within the environment (Campbell and Speldewinde, 2020). Gill (2012) explains that an affordance is an object where its function is perceived differently by each child. This area is a high affordance area offering many alternative functions from both the environment and the resources. In the Pagoda, the bench could offer a climbing affordance to one child but a covered affordance to another. Providing affordances within the environment allows children to externalise their natural ability to play with anything in a variety of ways. The way objects are perceived and the affordances they offer can be encompassed into a schema. Vernon (2016) explained that this allows the realisation of the consequences of actions and gives opportunities for adaptation and application of these schemata over a lifetime. He compares this to Piaget's work on schemas but criticises the instability of the observations that Piaget used, explaining that children may not verbally internalise these affordances in the same manner as adults. The practitioner when organising a learning environment can facilitate opportunities for children to access affordances alongside suitable resources or loose parts and support the internalisation of thoughts through sustained shared thinking or metacognitive talk that will lead to the creation of schemas and a comprehension of their actions. Assisting children in using verbal language as suggested by Vygotsky or symbols as supported by Dewey in a multimodal way will help children to externalise these thoughts (Aubrey and Riley, 2019).

Symbolic thinking leads to verbal communication, but practitioners can provide other ways for children to represent language (Aubrey and Riley, 2019). Reggio Emilia and Mosaic approach use multimodality that allows children to express themselves using a variety of different modes or objects giving freedom of choice, contributing to more advanced cognitive and holistic development (Brandao and Theodotou, 2020). Vygotsky, however, put more of an emphasis on spoken language for development. Encouraging children to externalise their thoughts through verbalisation, encourages social development and helps children to work through problems, processing the information to reach a conclusion (Aubrey and Riley, 2019). Developing these language skills allows for interaction with the educator or more knowledgeable other supporting developmental progression (Aubrey and Riley, 2019).

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