

ECEY5005: Awe and Wonder: Mathematics, Science and the Outdoors
(Portfolio)

Contents:

Page Number/s:	Portfolio Contents:
2	AI Declaration
3	<i>Section 1:</i> Photograph of chosen outdoor space
4-8	<i>Section 2:</i> Discussion – how the outdoor space can be utilised by children in the early years to explore and develop scientific and mathematical concepts? (1104 words)
9-12	<i>Section 3:</i> Risk – Benefit Assessment (1101 words)
13-18	<i>Section 4:</i> Discussion – Evaluation of how adults working with early years children can support and encourage them to engage with scientific and mathematical concepts in an outdoor environment. (2072 words)
19-24	Reference List

AI Declaration -

I acknowledge the use of Google Scholar [<https://scholar.google.com/>] between period:

(3/09/2025) - (04/10/2025) to help search for relevant academic journals and literature which are not always available via the university online library.

The following prompts were used:

- Children in the early years and outdoor learning
- The adult role in supporting mathematical and scientific concepts in the outdoors for children in the early years
- Metacognitive talk in the early years
- Affordance in the early years

I confirm that I have not presented any AI generated text as my own work. I confirm that I have copies of my drafts, notes, and other resources I used before, and after the use of AI tools which I may be asked to provide as evidence.

Section 1: Photograph of chosen outdoor space





Section 2: Discussion - how the outdoor space can be utilised by children in the early years to explore and develop scientific and mathematical concepts.

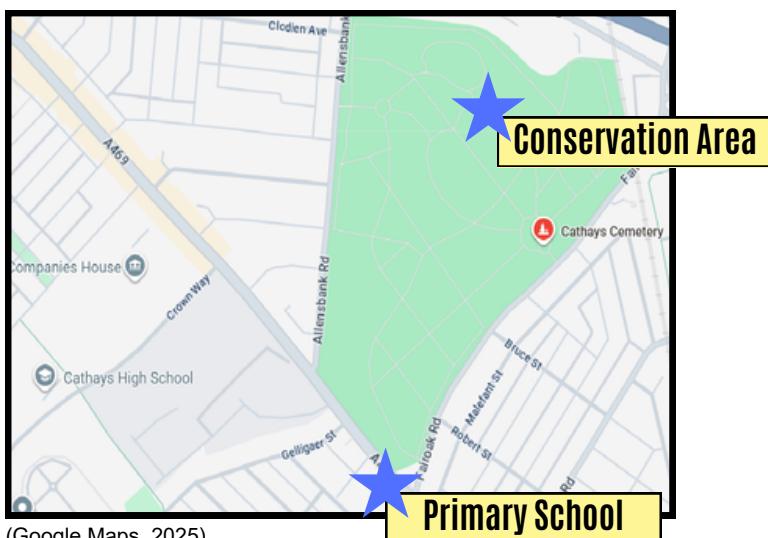
Background:

It is well known that being in nature can support children's learning and development in many ways (Tinney, 2023). Accessing learning opportunities in nature, however, can be more of a challenge for those that live in urban areas (Sugar, 2021). Alongside more limited availability of green spaces compared to rural areas, factors that can limit visits to suitable outdoor environments include a lack of funding and other resources such as clothing. Educators and caregivers need understanding and training in supporting outdoor learning opportunities, especially if a more urban environment means needing to think creatively about where to access nature.

Section two will discuss how a group of early years children from a local authority maintained primary school might use the Conservation Area at Cathays Cemetery to explore and develop their learning in both scientific and mathematical concepts.



*All images were taken at Cathays Cemetery Conservation Area, Cardiff



(Google Maps, 2025)

Visit Information:

Children - For the initial visit, a group of 12 children from a year one (ages 5/6) class, some of which will have additional learning needs (x 2).

Adults - The children will be supported by four adults; one class teacher, and three teaching support assistants. This high ratio will ensure that children are observed and assisted in their learning effectively.

Visit Information:



The children will walk from the school to the Conservation Area as a group cohort and will have opportunities to explore in smaller groups, supported by an adult member of staff. The children which require extra support will always have an adult with them. This would be the first school visit to the area for this group of children with the view to making regular visits throughout the year, which can support their learning of both mathematical and science related concepts. This initial visit took place on a dry autumn day.



The children will be given opportunities to explore the area independently, with educational staff being responsive to their organic questioning of the environment. The adults will support the children in their curiosity by asking questions to promote further thinking and understanding. Observing how the children use the space and what knowledge they are exploring and questioning will allow the adults to encourage learning of mathematical and scientific concepts.

Responding to observations, I may then provide different learning resources such as measuring tapes, magnifying glasses, or suggesting activities to explore next time.

Opportunities for exploration of mathematical concepts in this area:

The Curriculum for Wales (Welsh Government, 2022) outlines that play forms a central part in allowing for the learning and development of mathematical and numeracy skills in the early years. Alongside play, real-life experiences can help young learners make connections between new concepts and their own lives in mathematically rich environments both indoors and outdoors (Welsh Gov, 2020). Below are some examples of how the children visiting the Conservation Area might organically explore mathematical concepts that will allow them to develop skills within the five curriculum areas of learning (conceptual understanding, communication using symbols, fluency, logical reasoning and strategic competence) (Welsh Gov, 2020a):

Size, spatial awareness, measurement, positional language



Observing height differences - thinking about scale:

Children might say/ ask:

"Wow, look how tall that tree is!"

"Why are some trees taller?"

"Why aren't they the same size?"

Adults scaffold/support learning examples:

"Can you point out the tallest tree?"

"Are you taller than the tree?"

"Let's investigate more about different tree types to learn about how this might affect their growth"



Observing sizes - looking at the widths and positions of different tree trunks:

Children might say/ ask: **Adults scaffold/support learning examples:**

"Look at that big tree trunk!"

"Can you show me which one the widest?"

"I can't put my arms around it!"

"Shall we use a tape measure to see how big it is?"

"Can you show me which trunk is at the front, back, middle?"

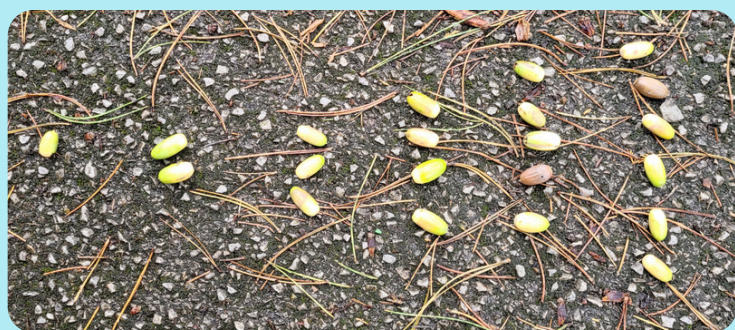
Other examples:

Finding different length sticks to measure



Finding different sized pine cones, which is bigger/smaller?

Using numbers and data



Finding nature's loose parts in the conservation areas such as acorns, pine cones, mushrooms, and sticks could be used by children to help engage with numeracy skills relating to quantities, such as counting, adding, subtracting, and dividing. This supports the development of mathematical language and basic computations.

Children might say/ ask: **Adults scaffold/support learning examples:**

"There's lots of acorns here!"



"We found mushrooms!"

"How many can you find, can you count them?"

"Are there more or less in this pile?"

"If we add another acorn, how many do we have?"

"If we take one away, how many do we have?"

"How many can you find, can you count them?"

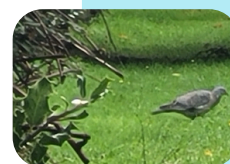


"Look- birds and squirrels!"



"Shall we count how many we see on our visit it today? We can count again next time and see if we see a different amount?"

"How many birds did you see all together? Were there more blackbirds?"



Opportunities for exploration of scientific concepts in this area:

Central to the Welsh Curriculum, especially in the Early Years, is the idea that natural environments afford rich learning experiences for children. This is particularly obvious in relation to exploring scientific concepts, many of which can be seen first hand in the natural world. The Curriculum for Wales encourages young learners to develop science skills in an integrated 'STEM' approach which encourages children to problem solve, think critically, demonstrate innovation and creativity, as well as learning to work and communicate with others (Welsh Gov, 2020a). There is also a strong emphasis on achieving science based learning objectives by using real-life, authentic experiences, as well as allowing for curiosity and exploration. Learning in such a way allows not only for meeting curriculum objectives in both science and mathematics, but also helps children to meet the requirements of the core Four Purposes of the Curriculum generally: Ambitious, capable learners; enterprising, creative contributors; ethical, informed citizens; and healthy, confident individuals (Welsh Gov, 2022b).

Exploring Habitats and Diversity



Noticing wildlife such as mini-beasts and squirrels at the Conservation area will allow children to become more aware of where and why living things might inhabit different spaces. Children could find out why certain animals live in different places, as well as looking at what they might do to survive there. They could compare different habitats and start to develop scientific language to describe these.

Seasons and Life-Cycles



Looking at different features in this natural environment can help children conceptualise life-cycles, seasonal change, processes of growth, development, age, decay and reproduction.



Weather



Children are able to notice changes in weather by looking at the sky, feeling temperatures and noticing water gathering in puddles or receptacles. They could develop scientific skills and understanding in future visits which may include using basic instruments to measure rainfall and temperature.



Forces



Children might say/ ask:

"Why did the tree break?"

"How did the tree fall over?"

"That tree has lots of bumps!"



Adults scaffold/support learning examples:

"Do you think this is heavy?"

"How heavy?"

"Is that rough or smooth?"



Light & Shade

There are many different trees and plants at the Conservation Area which create exciting spaces to explore. Children may notice that some areas are lighter than others - this is a good opportunity to learn about the physical properties of the natural world.



Section 3: Risk- Benefit Assessment

Location: Conservation Area at Cathays Cemetery, Cardiff (as detailed in photographic image - Section 1)

Activity: Exploring Mathematical and Scientific concepts in nature with a group of twelve year 1 pupils (5 - 6 years old)

Date: 08/09/2025

Review Date: 10/11/2025, review to be completed before next visit (Autumn 2), to allow for updates/amendments such as change in weather and associated risks

Proposed experiences/activities explored at location	How will the children benefit from these experiences/activities	Potential hazards and associated risks	Risk to who?	Precautionary measures to reduce risk of injury:	Risk rating post precautionary measures actioned *:
Outside environment with potential for variable weather conditions	Allows children to better understand outdoor environments and nature, as well as supporting areas such as: <i>cognitive development</i> experiences, e.g. understanding where water in puddles comes from, gives opportunities for children to identify weather related hazards themselves <i>promotes sensory and physical development</i> e.g. experiencing reactions to different temperatures, wind speed and balancing, reactions to different textures on the ground <i>emotional , social and mental well-being</i> e.g. opportunities for creative play (e.g. snow, puddle jumping, making shelters), helps children to adapt to different conditions and can build resilience, outdoors supporting mental health and wellbeing generally	- slips, trips, falls, cuts, bruising, sprains or potential serious/life changing injury/death caused by weather affects to ground surfaces (e.g ice), also storm/wind speed causing falling objects such as trees, building/ natural debris - sun/ extreme heat exposure has potential to cause heat stroke, sun burn, fainting, dehydration - cold temperature exposure can result in conditions such as hypothermia,muscle tension and pain - exposure to wet conditions can cause discomfort and distress if clothing is not suitable, drowning risk in water	Children and Adults	- Weather checks to be made using MET Office including local area checks. Re-schedule activity if weather is deemed too dangerous e.g. weather warning issued. Responsible adult to monitor weather associated risk throughout activity - Children and adults provided with appropriate clothing and equipment for predicted weather conditions. e.g. wellies and waterproofs for wet weather, sun-cream, hats and sufficient water for hot weather, warm layers for colder conditions. Some spare provision of items taken for children but also checked that they have appropriate clothing and equipment before prior - Comprehensive first-aid equipment, emergency contact device (phone), and required medication readily available, access to nearest shelter/safe place known	L

Proposed experiences/activities explored at location	How will the children benefit from these experiences/activities	Potential hazards and associated risks	Risk to who?	Precautionary measures to reduce risk of injury:	Risk rating post precautionary measures actioned *:
Exploring Cathays Cemetery and Conservation Area: variable terrain including uneven ground surfaces	Allows children to explore, learn and develop areas such as: <i>physical development</i>- promotes vestibular balance and gross motor skills, spatial awareness and coordination, builds confidence and sense of achievement, problem solving and resilience, building <i>social skills and confidence development</i>- team work opportunities (helping each other problem solve and navigate areas) - opportunity for children to assess own risk	slips, trips, falls, cuts, grazes, bruising, sprains or potential serious/life changing injury/death caused by uneven surfaces/ covered trip hazards such as memorial stones	Children and Adults	- Informing/ reminding children and adults of potential uneven ground and associated hazards prior and during visit e.g. reminding them walk carefully, slowly, being observant - Following public concrete walkway route when entering the cemetery until reaching conservation area - Comprehensive first-aid equipment, emergency contact device (phone), and required medication readily available - Promoting children's development of balance, gross motor, coordination and teamwork skills in other activities to assist knowledge, understanding and development in these areas prior to visit - Provision of appropriate clothing, especially footwear to navigate uneven ground carefully, e.g. closed toe shoes, boots, trainers	L/M
Observing and/or collecting objects/ living things found at the environment	- opportunities to learn and develop knowledge around concepts such as habitats, life-cycles, conservation, caring and respect for natural spaces and living things, properties of materials, supports schema, nature's loose parts - opportunities for children to assess own risk - multi- sensory experiences e.g. touching mud, different textures of plants, rocks, smelling flowers	- Potential sharp/dangerous objects such as glass, drug paraphernalia, animal faeces - Poisonous natural objects such as berries, fungi (risk of ingestion - children) - stings/bites from animals (dogs,cats, birds, squirrels, rodents), insects, plants	Children and Adults	- Discussions and learning around safe and unsafe items (e.g. litter, sharp objects) prior to visit - Adequate adult observation of children collecting/ touching objects found outdoors throughout visit - Respecting and not approaching animals found in nature, including dogs being walked in or exploring cemetery grounds - Comprehensive first-aid equipment, emergency contact device (phone), and required medication readily available (potential allergies to stings, bites) - hand hygiene, reminders of no objects in or near mouth - Assessment of poisonous/irritant causing plants (e.g. nettles) prior and during visit	L/M

*L- low risk| M= medium risk | H -high risk

Proposed experiences/activities explored at location	How will the children benefit from these experiences/activities	Potential hazards and associated risks	Risk to who?	Precautionary measures to reduce risk of injury:	Risk rating post precautionary measures actioned *:
Exploring Cathays Cemetery and Conservation Area: exploring a space that is open to the public	- Opportunity to learn about and assess own risk (e.g. stranger danger) - Learning about being respectful in public places, particularly sacred/places of significant importance/history such as cemeteries - Developing confidence and independence in unfamiliar environments - Learning how to seek out nature/ places of interest in urban environments - Caring for public places and nature	- Potential for interaction with strangers that may have inappropriate intentions, demonstrate challenging behaviours and or/language - Children getting lost	Children and Adults	- Discussions and learning around interactions with strangers and safety prior to visit - Reminders to children of leaving/walking protocol should they need to leave area promptly - Continuous observation of area by adults during visit to assess for opportunities for inappropriate interaction or witnessing of behaviours from public in area - Comprehensive first-aid equipment, especially emergency contact device (phone) and recognition of nearby safe places (Cathays library, local police station)	L/M
area that allows vehicle access for visitors and maintenance	- Opportunity to develop knowledge and practical experience of road safety and assessing associated risks - Opportunity to learn about caring for open spaces e.g. maintenance - cutting grass, looking after plants/trees - who does these jobs?	Potential for injury/risk of death from vehicle accident	Children and Adults	- Discussions and learning around road safety prior to and during visit - Continuous observation of area by adults during visit to acknowledge and prepare for the safe passing of nearby vehicles at the site	L/M

Proposed experiences/activities explored at location	How will the children benefit from these experiences/activities	Potential hazards and associated risks	Risk to who?	Precautionary measures to reduce risk of injury:	Risk rating post precautionary measures actioned *:
Exploring Cathays Cemetery and Conservation area: visiting an area of burial, historical interest	- Opportunity to develop knowledge or sites of historical interest - Learning about respect of sacred environments, people visiting and caring for the nature and memorials that exist there	- Potential for difficult or sensitive questions and/or conversations - Potential for feelings of anxiety towards unknown spaces, situations, trauma or previous experiences of similar environment visited in upsetting circumstances (e.g. family members funeral)	Children and Adults	- Discussion with children about the area they are visiting before visit (<i>what is it? what can we expect to see?how should we behave?</i>) - clear, age appropriate, sensitive conversations, explanations and responses to questions children may have - reassurance from adults that focus on respect and care of the environment	M -H medium- high potential for children to question/discuss subjects around death, grief, negative experiences
Outward and return journey to the site from primary school	- Opportunity to develop knowledge and practical experience of road safety and assessing associated risks - Opportunity to learn about planning journeys and activities (e.g. how can we get there, how long might it take? what do we need to wear/ bring with us?) - developing communication, team work, (e.g. walking partners) - developing confidence in visiting unfamiliar places	- Potential for injury/risk of death from vehicle accident - slips/trips/falls/injury from uneven ground or potential hazards such as road works on walkways - litter/dangerous objects or mess (e.g. dog faeces) - potential for interaction or viewing of inappropriate behaviour from strangers	Children and Adults	- Walking protocol completed and submitted to the school office/management - Comprehensive first aid and emergency contact device - Continuous observation of potential hazards/risks prior to and during the journey - ensure suitable clothing and equipment is available for all on trip (hi-vis vests, weather appropriate clothing) - regular headcounts/ staffing ratios observed - recording,follow- up/debriefing of any incidents and concerns	M

Section 4: Discussion – With reference to theory and research, evaluate how adults working with early years children can support and encourage them to engage with mathematical and scientific concepts in an outdoor environment.

Piaget famously described children as “little scientists,” naturally motivated to explore, experiment, and construct their own understanding of the world (Halpenny and Pettersen, 2014). This framing is particularly useful in considering how adults can best support children’s mathematical and scientific learning in the early years. Rather than positioning themselves as the sole transmitters of knowledge, adults are increasingly understood as facilitators, working in partnership with children to guide, extend, and scaffold their explorations (Watts, 2020). Outdoor environments offer not only physical space for movement and play (Learning Through Landscapes, 2025), but also a dynamic and ever-changing set of resources that can stimulate curiosity, creativity, and conceptual thinking (Prisk and Cusworth, 2018), as well as bringing about concern and care for nature as a precious resource (Ärlemalm-Hagsér and Elliott, 2018). Wales benefits from providing unique and inspiring opportunities for learning in nature (Active Learning Centres, 2024) and the 2022 Curriculum for Wales (Welsh Government, 2022) provides a strong focus on outdoor learning and its benefits (Tinney, 2023).

Whilst the outdoor environment can support many areas of learning, this essay will evaluate how adults can encourage and support early years children to engage specifically with mathematical and scientific concepts in outdoor contexts, drawing on relevant theories and research.

Affordances of Outdoor Learning

Affordance theory provides a valuable lens for understanding how environments shape learning opportunities. Barrable defines affordance as “the relationship between an agent and a physical system or environment they find themselves in.” (Barrable, 2022, p.81). The concept originates from Gibson’s ecological theory, which explores the “complementarity of the animal and the environment” (Gibson, 1979, p.127), emphasising what the environment offers an individual and how they engage with it.

Educational researchers have extended this concept to the study of learning environments. Waters (2017) highlights that affordances of any given environment can enhance or restrict children’s engagement, depending on how spaces are structured and used. Woods (2017) provides an overview of how the outdoors supports development through play, connections with nature, multi-sensory experiences, challenge, and controlled risk-taking. This supports the idea of nature as “the richest environment that can feed their cognition and enhance their thinking skills, creativity, and development” (Edward *et al.*, 2024, p. 10).

Curriculum frameworks reflect the importance of outdoor learning. In Wales, Wainwright (2021) describes how the Foundation Phase emphasises the need for learning “to take place when and where it is most appropriate to the needs of the learner” (Wainwright, 2021, p. 569). This may require providers to move away from traditional ways of seeing the indoor and outdoor learning environments as separate, and to plan their activities with the possibility of free-flowing movement in mind (Barfod and Mygind, 2022). Entire pedagogical movements such as Forest Schools have also developed from the rationale that nature-based learning affords unique learning possibilities for children (Clipa and Cimpan, 2020; Matthews and Lippman, 2020).

Wiedel-Lubinski (2020) argues that “when learning moves outdoors, curiosity drives a great deal of interest in STEM-based concepts” (Wiedel-Lubinski, 2020, p. 183). A recent review by Trina *et al.* (2024) demonstrates the breadth of mathematical and scientific concepts supported by outdoor learning environments, noting that they provide multiple “learning affordances.” These include natural materials such as acorns, twigs, and pinecones, which connect to Nicholson’s theory of loose parts (Nicholson, 1971), as well as dynamic features such as slopes, puddles, and shadows. Such affordances invite exploration of mathematical ideas such as counting, quantities, and probability, and of scientific ideas such as forces, liquids, and states of matter (Robertson, 2017; Wiedel-Lubinski, 2020; Won & You, 2022).

Yet affordances alone do not guarantee conceptual engagement. Waters (2017) stresses that children’s experiences may be substantially different from adults in the same space, meaning that opportunities must be carefully interpreted. Bilton and Crook (2016) argue that adults need to ‘wipe the slate clean’ when accompanying children outdoors, approaching with openness rather than assumptions based on previous behaviour, usually demonstrated in an indoor classroom environment. A further influential factor is also the attitude of the supporting adult and their willingness to enable, engage with and support outdoor learning (Woods, 2017; Wilson, 2018; Edwards, 2022). For example, educational administrators and senior leadership teams (Wiedel-Lubinski, 2020), and parents and caregivers, may have a range of attitudes towards outdoor learning and the potential risks it can involve (McFarland, L. and Laird, S. G. (2018).

Supporting Mathematical Engagement Outdoors

Mathematical knowledge in the early years develops sequentially, with each new idea building upon earlier experiences (Haylock and Manning, 2019). For this reason, adults supporting children’s mathematical development outdoors must strike a balance between structured activities and playful exploration. Clements and Sarama (2020) argue that whilst mathematics requires systematic progression, it is most effectively learned when integrated into meaningful contexts rather than isolated exercises.

Nicholson's (1971) loose parts theory is particularly relevant here, because open-ended materials such as sticks, stones, acorns, and pinecones afford a wealth of mathematical explorations. For example, children might group or sort pinecones by size, compare the lengths of sticks, or count stones to construct patterns. Guidance from Estyn (Estyn, 2024) and Play Wales (2017) both emphasise how adults can encourage children's natural curiosity, play, and ability to problem solve when approaching mathematical concepts. For example, adults can provide measuring tools, organise resources, and model mathematical language. Robertson (2017) describes how simple interventions such as asking "which is heavier?" or "how many will fit in this container?" can transform spontaneous play into conceptual engagement with measurement, mass, weight, probability, or volume.

The role of the adult as a facilitator aligns with Vygotsky's theory of the Zone of Proximal Development (ZPD) (Aubrey and Riley, 2016; MacBlain, 2018), which describes the difference between what a child can do independently and what they can achieve with support. By scaffolding children's interactions with natural materials, adults can extend their reasoning beyond the immediate and concrete. Importantly, scaffolding should gradually fade as children become more confident, allowing them to internalise mathematical concepts. Clark's (2023) notion of 'slow knowledge' is relevant here, suggesting that children need time to consolidate understanding and that adults should resist the urge to rush progress.

Keith (2018) highlights how schematic behaviours, such as repeatedly filling and emptying containers or lining up sticks, are not random but reflect emerging mathematical reasoning. These behaviours can be supported by adults through the introduction of positional language (e.g. "longer than," "shorter than," "biggest," "smallest") and through prompting comparison and ordering. Over time, children become more able to articulate and apply these concepts independently, showing how nature's loose parts can support their schematic development (Boulton and Thomas, 2022).

Supporting Scientific Engagement Outdoors

Wiedel-Lubinski (2020) describes how outdoor contexts are uniquely suited to science learning, and how children's "curiosity drives a great deal of interest in STEM-based concepts" (Wiedel-Lubinski, 2020, p.183). Outdoor environments provide children with direct contact with the

phenomena that underpin scientific concepts and lend themselves to experimentation, problem-solving, and prediction.

Adults can guide and deepen this engagement by “providing stimulating environments and carefully designed experiences with the natural world” (Worth, 2020, p.7). Science learning outdoors is not about replicating laboratory experiments but about recognising everyday opportunities for inquiry. For example, rolling pinecones or stones down a slope invites exploration of speed, force and gravity. Puddles and streams provide a natural setting for investigating liquids, flow, and absorption, while building dams from mud or sticks links to concepts of states of matter and resistance. Opportunities to plant seeds and observe their growth also connect directly to plant science and the scientific discovery process, as shown in a recent US study where preschool and kindergarten teachers used an immersive sweet pea project to develop children’s understanding of plant science (Chen *et al.*, 2023).

Again, children’s engagement with scientific concepts can be supported by adults who provide scaffolding for their learning. For example, Tunnicliffe (2015) describes how it is important not to tell children what they see, but rather to encourage their own curiosity and meaning-making. However, research indicates that some adults working in early year’s education may lack confidence in their own scientific knowledge, which can inhibit their willingness to support inquiry (Barrable *et al.*, 2022). Yet this limitation can also be reframed as a strength: when adults position themselves as co-learners, they model the processes of investigation, error, and revision, which is all part of the collaborative and experimental nature of scientific work (Worth, 2020).

The Role of Metacognitive Talk

Another important part of supporting mathematical and scientific learning outdoors is the development of metacognition. Metacognition refers to the processes of planning, monitoring, regulating, and evaluating one’s performance while completing a task (Flavell, 1979). It is strongly associated with the development of higher-order cognitive skills, including problem-solving, creativity, and critical thinking (Mulholland *et al.*, 2025). Outdoor activities such as gardening can foster reflection, planning, and evaluation, core aspects of metacognition, through sustained, hands-on interaction with nature (Tovey and Skolits, 2022).

A key component of developing metacognition is the use of ‘metacognitive talk’, i.e. using dialogue and communication to verbalise their reasoning and reflection (Mercer and Mannion, 2018). This aligns with Vygotsky’s view of cognitive development as something that happens through interpersonal communication and social relationships (Vygotsky, 1978). Similarly, Froebel highlighted how interactions with enabling adults in natural settings offer opportunities for symbolic and reflective thinking (Edward *et al.*, 2024).

In practice, adults can use metacognitive talk to encourage reflective thinking in the outdoor environment (Muijs and Bokhove, 2020). For example, when demonstrating a measurement activity, an adult might verbalise their reasoning: “I wonder which stick is longer? I’ll line them up together. Does that give me the answer I expected? What could I try differently?” Such self-talk demonstrates the processes of planning, monitoring, and evaluating, providing children with a model for their own reflective thinking.

Despite its benefits, research suggests that strategies like metacognitive talk remain underdeveloped in practice. Perry *et al.* (2019) note that it is often neglected in policy, while Muijs and Bokhove (2020) find that teachers’ understanding of metacognition is frequently limited, leading to misconceptions and weak implementation. Mulholland *et al.* (2025) argue that structured training programmes are needed to support practitioners in embedding metacognitive strategies into everyday teaching, particularly in problem-solving contexts.

The Role of the Adult: Opportunities and Challenges

Across both mathematics and science, the adult’s role is best understood as that of a facilitator rather than an instructor. Tunnicliffe (2015) emphasises that science learning in particular should not involve telling children what they see, but encourage their curiosity and exploration through questions, prompts, and shared attention. Adults can support this by asking open-ended questions, listening carefully to children’s ideas, and providing opportunities for them to test and refine their thinking. Careful observation, evaluation, and reflection are also important processes which help adults tailor their support to the needs of each individual child and task (Bilton *et al.*, 2017).

Rekers (2022) describe how outdoor environments can provide inclusive opportunities for children who may struggle indoors, including those with behavioural challenges. At the same time, some children may find sensory-rich environments more difficult, such as autistic learners or those with heightened sensory sensitivities, meaning that sensitive facilitation is needed (Coughlan and Lynch, 2024). Woods (2017) similarly highlights the importance of adult attitudes, noting that enthusiasm and willingness to explore strongly influence the richness of children’s engagement. There are also practical and resource constraints on providing meaningful outdoor learning experiences, that include exploration, movement, gardening, play, and security (Edward *et al.*, 2024). These challenges underline the importance of professional development, resourcing, and thoughtful design if adults are to fully realise the potential of outdoor environments for learning (Waters and Rekers, 2019).

Conclusion

In conclusion, outdoor environments afford unique opportunities for engaging children in mathematics and science, from counting and measuring loose parts to observing forces, liquids, and growth processes. The role of the adult is central in transforming these affordances into learning by providing a range of outdoor experiences that support children's natural capacity for awe and wonder. Their role needs to strike a balance between the diverse needs, skills, and interests of children, and between providing structure, guidance, and allowing learning to be led by the child (Woods, 2017). Beyond children's mathematical and scientific engagement, learning outdoors is an important part of supporting the holistic development of young learners, helping to cultivate reflective, creative, and ethically aware citizens.

Reference List

- Active Learning Centres (2024) *Why outdoor learning thrives in wales*. Available at: <https://activelearningcentres.co.uk/blog/why-outdoor-learning-thrives-in-wales/>. (Accessed: 19 September 2025).
- Aubrey, K. and Riley, A. (2016) *Understanding & using educational theories*. 1st edn. London: SAGE Publications Ltd.
- Barfod, K. and Mygind, E. (2022) 'Udeskole—Regular teaching outside the classroom', in Jucker, R. and von Au, J. (eds) *High-quality outdoor learning: Evidence-based education outside the classroom for children, teachers and society*. Cham: Springer International Publishing, pp. 287-297.
- Barrable, A. (2022) *Nature-based learning: improving learning and well-being by teaching with nature in mind*. Wales: Independent Thinking Press.
- Barrable, A., Touloumakos, A., & Lapere, L. (2022) 'Exploring student teachers' motivations and sources of confidence: The case of outdoor learning', *European Journal of Teacher Education*, 45(3), 356-372. Available at: <https://doi.org/10.1080/02619768.2020.1827386>
- Bilton, H. and Crook, A. (2016) *Exploring outdoors ages 3-11: a guide for schools*. 1st edn. Abingdon, Oxon: Routledge.
- Bilton, H., Bento, G. and Dias, G. (2017) *Taking the first steps outside: under threes learning and developing in the natural environment*. 1st edn. Abingdon, Oxon: Routledge.
- Boulton, P. and Thomas, A. (2022) 'How does play in the outdoors afford opportunities for schema development in young children?', *International Journal of Play*, 11(2), pp. 184–201. Available at: <https://doi.org/10.1080/21594937.2022.2069348>
- Chen, S., Guo, M. and Dousay, T. A. (2023) 'Grow to learn: a metacognitive approach to early childhood teachers' science professional development', *Research in Science & Technological Education*, 43(2), pp. 390–410. Available at: <https://doi.org/10.1080/02635143.2023.2279076>
- Clark, A. (2023) *Slow knowledge and the unhurried child. Time for slow pedagogies in early childhood education*. Abingdon, Oxon: Routledge.
- Clements, D.H. and Samara, J. (2020) 'Mathematics in early-learning environments', in Waite-Stupiansky, S. and Cohen, L.E. (eds) *STEM in early childhood education: how science, technology, engineering, and mathematics strengthen learning*. Abingdon, Oxon: Routledge, pp. 63-80.

- Clipa, O. and Cilimban, E. (2020) *Social-emotional competences of preschoolers: the impact of outdoor educational activities*. Bern: Peter Lang International Academic Publishing Group. Available at: <https://doi.org/10.3726/b17740>.
- Coughlan, M., & Lynch, H. (2024). "Can I Play Too?" A qualitative study of outdoor play and participation among autistic preschoolers. *The American Journal of Occupational Therapy*, 78(4), 7804185130. Available at: <https://doi.org/10.5014/ajot.2024.050732>
- Downs, E (2025) *Cathays Cemetery Conservation Area* [Photograph].
- Edward, L., Kamel, S., & Khodeir, L. (2024) 'Impact of Biophilic Design on Supporting Metacognitive Thinking in Early Childhood in Childcare Centers: A Multidisciplinary Study', *ARCHive-SR*, 8(1), 01-23. Available at: <https://doi.org/10.21625/archive.v8i1.1053>
- Edwards, M. (2022). *Myth busting: Why bad weather isn't an obstacle to outdoor learning*. Learning through Landscapes. Available at: <https://ltl.org.uk/news/myth-busting-bad-weather-outdoor-learning/>. (Accessed: 17 September 2025).
- Estyn (2024) *How to facilitate a child centred approach using loose parts to enhance creativity, resilience and collaborative skills*. Available at: <https://estyn.gov.wales/improvement-resources/how-to-facilitate-a-child-centred-approach-using-loose-parts-to-enhance-creativity-resilience-and-collaborative-skills/>. (Accessed: 19 September 2025).
- Eva Årlemalm-Hagsér, E. and Elliott, S. (2018) 'Transcultural explorations in nature-based early childhood education', in Becker, P., Loynes, C., Humberstone, B. and Schirp, J. (eds) *The changing world of outdoor learning in Europe*. 1st edn. Abingdon, Oxon: Routledge.
- Flavell, J. H. (1979) 'Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry', *American psychologist*, 34(10), p.906. Available at: <https://doi.org/10.1037/0003-066X.34.10.906>
- Gibson, J.J. (1979) *The ecological approach to visual perception*. Boston: Houghton-Mifflin.
- Google Maps (2025) *Cathays Cardiff* [online map screenshot]. Available at: <https://www.google.com/maps> (Accessed: 14 September 2025).
- Halpenny, A.M. and Petterson, J. (2014) *Introducing Piaget: a guide for practitioners and students in early years education*. 1st edn. Abingdon, Oxon: Routledge.
- Haylock, D. and Manning, R. (2019) *Mathematics explained for primary teachers*. 6th edn. London: SAGE Publications Ltd.
- Keith, L. (2018) *Developing young children's mathematical learning outdoors. Linking pedagogy and practice*. Abingdon, Oxon: Routledge.

- Learning Through Landscapes (2025) *Attainment: the impacts of outdoor learning and play*. Available at: <https://ltl.org.uk/news/attainment-the-impacts-of-outdoor-learning-and-play/>. (Accessed: 18 September 2025).
- MacBlain, S. (2018) *Learning theories for early years practice*. 1st edn. London: SAGE Publications Ltd.
- Matthews, E., & Lippman, P. C. (2020) 'The design and evaluation of the physical environment of young children's learning settings', *Early Childhood Education Journal*, 48(2), 171-180. Available at: <https://link.springer.com/article/10.1007/s10643-019-00993-x>
- McFarland, L. and Laird, S.G. (2018) 'Parents' and early childhood educators' attitudes and practices in relation to children's outdoor risky play', *Early Childhood Education Journal*, 46(2), pp.159-168. Available at: <https://link.springer.com/article/10.1007/s10643-017-0856-8>
- Mercer, N. and Mannion, J. (2018) *Oracy across the welsh curriculum a research-based review: key principles and recommendations for teachers*. Available at: <https://oracycambridge.org/wp-content/uploads/2018/07/Oracy-across-the-Welsh-curriculum-July-2018.pdf>. (Accessed: 26 September 2025).
- Muijs, D., & Bokhove, C. (2020) *Metacognition and self-regulation: evidence review*. London: Education Endowment Foundation. Available at: <https://eric.ed.gov/?id=ED612286>. (Accessed: 27 September 2025).
- Mulholland, K., Gray, W., Counihan, C., & Nichol, D. (2025) 'Stepping stones: adopting a fading programme design to promote teachers' use of metacognitive strategies for mathematical problem solving', *Education Sciences*, 15(7), 892. Available at: <https://doi.org/10.3390/educsci15070892>
- Nicholson, S. (1971) 'How not to cheat children, the theory of loose parts', *Landscape architecture*, 62(1), 30-34
- Perry, J., Lundie, D., & Golder, G. (2019) 'Metacognition in schools: what does the literature suggest about the effectiveness of teaching metacognition in schools?', *Educational Review*, 71(4), 483-500. Available at: <https://doi.org/10.1080/00131911.2018.1441127>
- Play Wales (2017) *Resources for playing -providing loose parts to support children's play*. Available at: <https://play.wales/wp-content/uploads/2023/03/loose-parts-toolkit.pdf>. (Accessed: 19 September 2025).

- Prisk, C. and Cusworth, H. (2018) *From muddy hands and dirty faces... to higher grades and happy places. Outdoor learning and play at schools around the world*. Available at: <https://outdoorclassroomday.org.uk/wp-content/uploads/sites/2/2018/11/Muddy-Hands-FINAL.pdf>. (Accessed: 14 September 2025).
- Rekers, A. (2022) 'Using an environmental affordance perspective to consider children's 'challenging behaviour' in the classroom and at Forest School', in Murphy, A. and Conn, C. (eds) *Inclusive pedagogies for early childhood education: respecting and responding to differences in learning*. Abingdon, Oxon: Routledge, pp. 158-174.
- Robertson, J. (2017) *Messy maths: a playful, outdoor approach for early years*. Carmarthen, Wales: Independent Thinking Press.
- Sugar, S. (2021) *The necessity of urban green space for children's optimal development*. Available at: <https://www.unicef.org/documents/necessity-urban-green-space-childrens-optimal-development>. (Accessed: 12 September 2025).
- Tinney, G. (2023) 'Big changes! The great outdoors and the curriculum for wales', *FORUM* 65 (1) pp. 63-75. Available at: <https://doi.org/10.3898/forum.2023.65.1.09>
- Tovey, T. L., & Skolits, G. J. (2022) 'Conceptualizing and engaging in reflective practice: experienced evaluators' perspectives', *American Journal of Evaluation*, 43(1), 5-25. Available at: <https://doi.org/10.1177/109821402098392>
- Trina, N.A., Monsur, M., Cosco, N., Shine, S., Loon, L. and Mastergeorge, A. (2024) 'How do nature-based outdoor learning environments affect preschoolers' STEAM concept formation? A scoping review', *Education Sciences*, 14(6), p.627. Available at: <https://doi.org/10.3390/educsci14060627>
- Tunnicliffe, S.D. (2015) *Starting inquiry-based science in the early years: look, talk, think and do*. 1st edn. Abingdon, Oxon: Routledge.
- Vygotsky, L.S. (1978) *Mind in society: the development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Wainwright, N. (2021) 'The foundation phase in wales, outdoor learning and motor development', *Journal of Physical Education and Sport*, 21, pp. 567-573. Available at: DOI:10.7752/jpes.2021.s1064
- Waters, J. (2017) 'Affordance theory in outdoor play', in Waller, T., Ärlemalm-Hagsér, E., Beate Hansen Sandseter, E., Lee-Hammond, L., Lekies, K. and Wyver, S. (eds) *The sage handbook of outdoor play and learning*. London: SAGE Publications Ltd, pp. 40-54.

- Waters, J., & Rekers, A. (2019) 'Young children's outdoor play-based learning', *Encyclopedia on early childhood development*. Available at: <https://www.child-encyclopedia.com/outdoor-play/according-experts/young-childrens-outdoor-play-based-learning>. (Accessed: 25 September 2025).
- Watts, A. (2020) *Outdoor learning through the seasons: an essential guide for the early years*. 2nd edn. Abingdon, Oxon: Routledge.
- Welsh Government (2020) *Mathematics and numeracy: introduction*. Available at: <https://hwb.gov.wales/curriculum-for-wales/mathematics-and-numeracy/>. (Accessed: 17 September 2025).
- Welsh Government (2020a) *Science and technology: introduction*. Available at: <https://hwb.gov.wales/curriculum-for-wales/science-and-technology>. (Accessed: 19 September 2025).
- Welsh Government (2022) *Curriculum for wales*. Available at: <https://hwb.gov.wales/curriculum-for-wales/>. (Accessed: 19 September 2025).
- Welsh Government (2022a) *Mathematics and numeracy: designing your curriculum*. Available at: <https://hwb.gov.wales/curriculum-for-wales/mathematics-and-numeracy/designing-your-curriculum/>. (Accessed: 19 September 2025).
- Welsh Government (2022b) *Developing a vision for curriculum design*. Available at: <https://hwb.gov.wales/curriculum-for-wales/designing-your-curriculum/developing-a-vision-for-curriculum-design>. (Accessed: 21 September 2025).
- Wiedel-Lubinski, M. (2020) 'Stem in outdoor learning: rooted in nature', in Waite-Stupiansky, S. and Cohen, L.E. (eds) *STEM in early childhood education: how science, technology, engineering, and mathematics strengthen learning*. Abingdon, Oxon: Routledge, pp. 182-205.
- Wilson, R. (2018) *Nature and young children: encouraging creative play and learning in natural environments*. 3rd edn. Abingdon, Oxon: Routledge.
- Won, H. and You, H. (2022) 'Next- generation science and engineering teaching practices in a preschool classroom', in Ampartzaki, M. and Kalogiannakis, M. (eds) *Early childhood education - innovative pedagogical approaches in the post-modern era*. IntechOpen. Available at: <http://dx.doi.org/10.5772/intechopen.98078>.
- Woods, A. (2017) *Child-initiated play and learning: planning for possibilities in the early years*. 2nd edn. Abingdon, Oxon: Routledge.
- Woods, A. (2017) *Elemental play and outdoor learning: young children's playful connections with people, places and things*. 1st edn. Abingdon, Oxon: Routledge.

Worth, K. (2020) '*Science in early learning environments*', in Waite-Stupiansky, S. and Cohen, L.E. (eds) *STEM in early childhood education: how science, technology, engineering, and mathematics strengthen learning*. Abingdon, Oxon: Routledge, pp. 4-21.