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National Council for Curriculum and Assessment

Enacting the curriculum:

Guidance for teachers' preparation in Science, Technology, Engineering and Mathematics (STEM) Education



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Enacting the curriculum:

Guidance for teachers' preparation in Science, Technology, Engineering (STE) Education

Introduction

The successful enactment of the *STE Education* specification relies on effective preparation for learning, teaching and assessment by teachers and schools. This is about bringing to life what is set down in the specification and embedding it in children's Learning Experiences that reflect the vision of the curriculum. This involves purposeful engagement with the specification and its supports, as well as the development of whole-school curriculum plans and whole-school agreed approaches to ensure high quality Learning Experiences are provided for every child.

This guidance offers practical, accessible support for designing playful, engaging Learning Experiences in line with the *Primary Curriculum Framework* and the *STE Education* specification. Teachers' preparation for effective learning, teaching and assessment enables them to make purposeful and informed decisions when working with the specification.

Teacher agency is central to this process. Teachers exercise agency by making professional decisions based on children's interests, curiosities and prior learning, and on the curriculum and whole-school approaches. The opportunities for agency available to teachers support preparation for Learning Experiences that are responsive to the unique context of their school. Also important is the recognition and nurturing of children's agency as their capacity to act on, participate in, and make choices about their learning within STE Education. Throughout this guidance there are prompts, suggestions and reflections designed to foreground both child and teacher agency as central to effective preparation.

This guidance provides the basis for schools' and teachers' preparation with the *STE Education* specification. This guidance complements the following materials:

- *Whole-School Curriculum Planning: Guidance for all Primary and Special Schools*
- *Preparation for Learning, Teaching and Assessment: Updated Guidance for all Primary and Special Schools*
- Updated *Assessment Guidance for Primary and Special Schools*
- Pedagogy and inclusion support materials.

To access these materials visit the Primary Curriculum Toolkit on **www.curriculumonline.ie**.

The *Science, Technology, Engineering and Mathematics (STEM) Education* specification is presented in three parts:

- The *Science, Technology and Engineering (STE) Education* specification
- An Approach to Integrated STEM Learning
- The *Primary Mathematics Curriculum*.

Guidance for teachers' preparation in this document is presented in the same three parts:

- Enacting the curriculum: Guidance for teachers' preparation in Science, Technology and Engineering (STE) Education
- Guidance for teachers' preparation: An Approach to Integrated STEM Learning
- Enacting the curriculum: Guidance for teachers' preparation in Mathematics.

Linking teachers' preparation to Whole-School Curriculum Planning

Individual teachers' preparation does not take place in isolation. It is shaped by the *Science, Technology and Engineering Education* specification, collaborative Whole-School Curriculum Planning, School Self-Evaluation and Action Planning. These all work together to guide effective learning, teaching and assessment.

Whole-School Curriculum Planning is especially important. It helps schools to agree on a shared approach to using the *Science, Technology and Engineering Education* specification. This includes the sequencing of children's learning across Stages 1 – 4, and how Learning Outcomes, Elements, Pedagogical Approaches and Assessment Guidance are used.

Following the process in *Whole-School Curriculum Planning: Guidance for all Primary and Special Schools* will lead to the successful development of a Whole-School Curriculum Plan for Science, Technology and Engineering Education. The plan should set out the agreed approaches which are necessary for teachers in a particular school context working with chapters 5 and 6.

The Whole-School Curriculum Plan acts as a guide for teachers' individual preparation. Teachers should align their preparation with both the specification and the school's agreed plan. This helps ensure consistency between whole-school planning and classroom practice.

Within this guidance, prompts are included to help guide schools when considering Whole-School Curriculum Planning. This is a non-exhaustive list and schools may adapt or add to them based on their own context.



Science, Technology and Engineering Education specification

The *STE Education* specification is organised into six interrelated strands. These strands describe the broad areas of learning within Science, Technology and Engineering (STE) Education. The strands remain consistent across all stages of the specification and reflect six major areas of STE learning:

- Nature of STEM
- Living things
- Materials
- Energy and forces
- Technology
- Engineering.

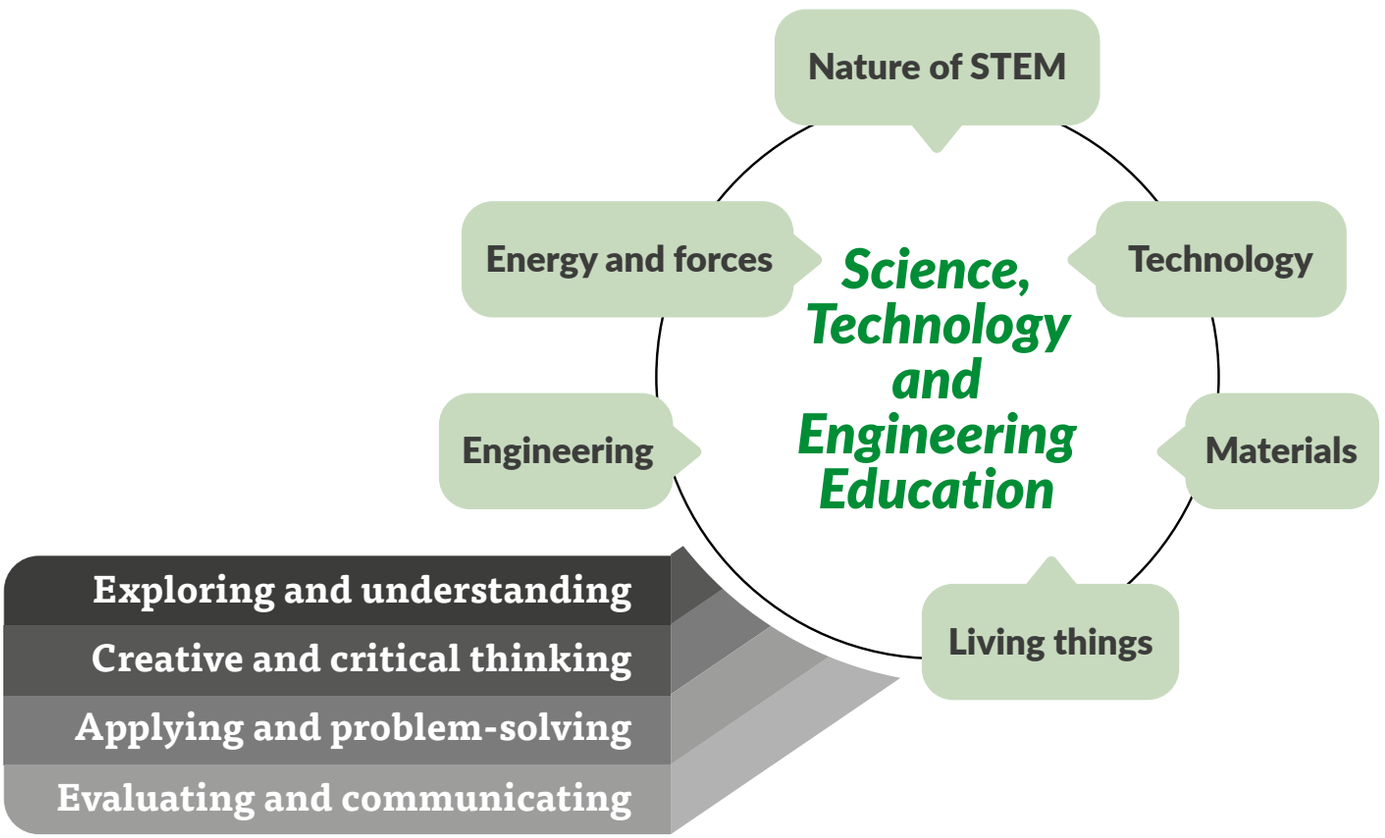


Figure 1: The Strands and Elements of the *STE Education* specification

The strands provide a practical structure for supporting preparation for learning, teaching and assessment. Each strand is important, and teachers should consider all STE Education strands in their preparation throughout the year.

In practice, learning, teaching and assessment often move fluidly across strands, and natural overlaps may occur. Teachers may choose to begin with any of the strands in their preparation.

How children learn is as important as what they learn. Figure 1 represents the relationship between the Strands (the 'what' of STE Education learning) and the Elements (the 'how' of STE Education learning).

Elements describe the STE Education processes. They are:

- Exploring and understanding
- Creative and critical thinking
- Applying and problem-solving
- Evaluating and communicating.

The Elements in STE Education align closely with Scientific inquiry, Design thinking and Computational thinking. When engaged, the Elements activate key STE learning in and across strands. In preparing for STE Education learning, consideration should be given to both what and how children will learn.

Considerations for Whole-School Curriculum Planning

Schools can:

- ensure breadth, balance and inclusive participation for all children across all stages
- use the Elements as a guide to the 'how' of children's learning.



Key Competencies, Learning Outcomes, Focus(es) of Learning and Learning Experiences

Key Competencies

The key competencies are central to children's learning and development and require sustained ongoing attention. Accordingly, they are embedded through all Learning Outcomes in Chapter 5. In preparing for STE Education, it is essential teachers provide opportunities for children to develop as active learners, communicators and users of language, creative thinkers, mathematical learners, digital learners and active citizens while developing their understanding of being well. This requires intentionality and therefore teachers should be mindful of how the key competencies, including their attributes, are being realised through the curriculum.

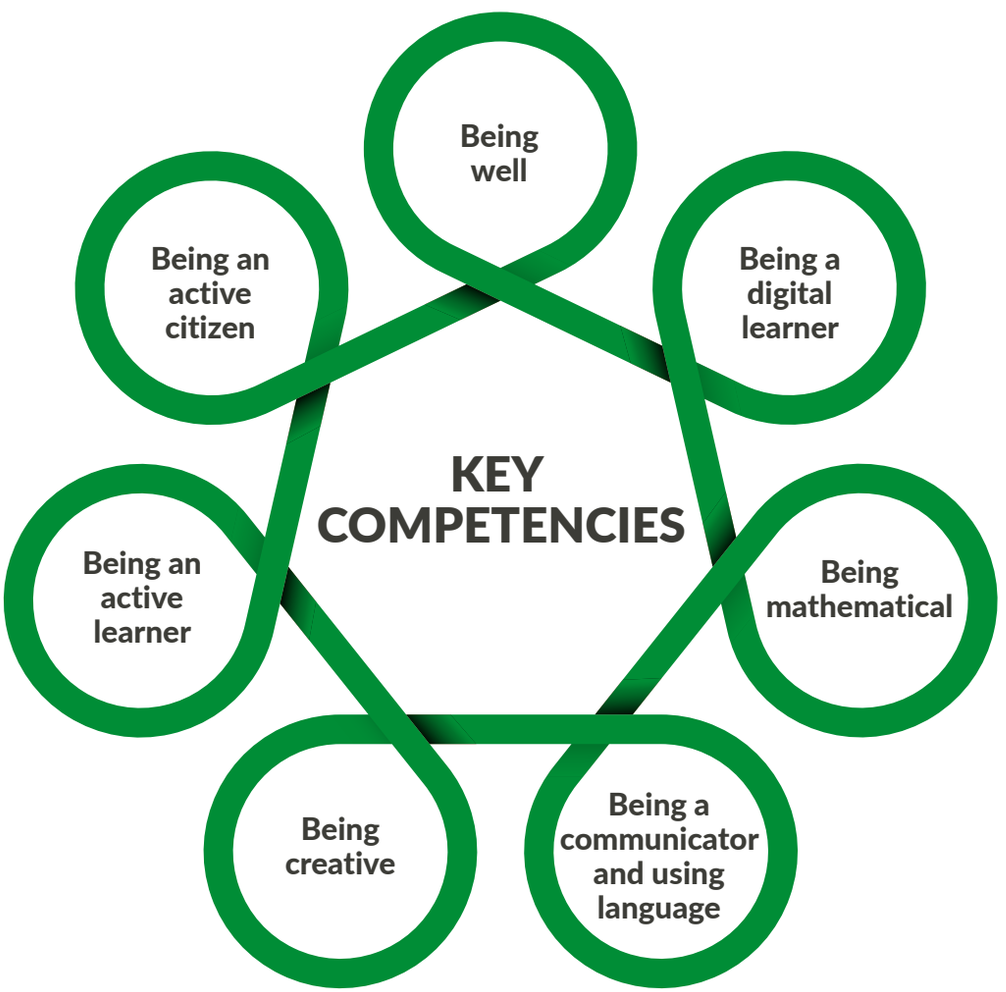


Figure 2: Key competencies

As outlined below, the Learning Outcomes anchor preparation; the Focus(es) of Learning clarifies what children will learn next; and the Learning Experiences provide appropriately playful and engaging opportunities for all children.

Learning Outcomes

As a teacher prepares for learning, teaching and assessment, all decisions should be informed by:

- Knowledge of children and their prior learning, strengths, abilities, interests and needs
- Knowledge of the curriculum, including its vision, principles, key competencies and Learning Outcomes in the specifications
- Knowledge of pedagogy and assessment, including approaches described within the specifications.

The processes of learning, teaching and assessment are complex, fluid and dynamic; while being complementary to each other. In recognition of this reality 'Entry Points' are where a teacher begins their preparation in working with the Learning Outcomes. There are many possible entry points when preparing for learning and teaching including Learner entry points, Curriculum entry points and Contextual entry points. The entry points are examples, not a checklist.

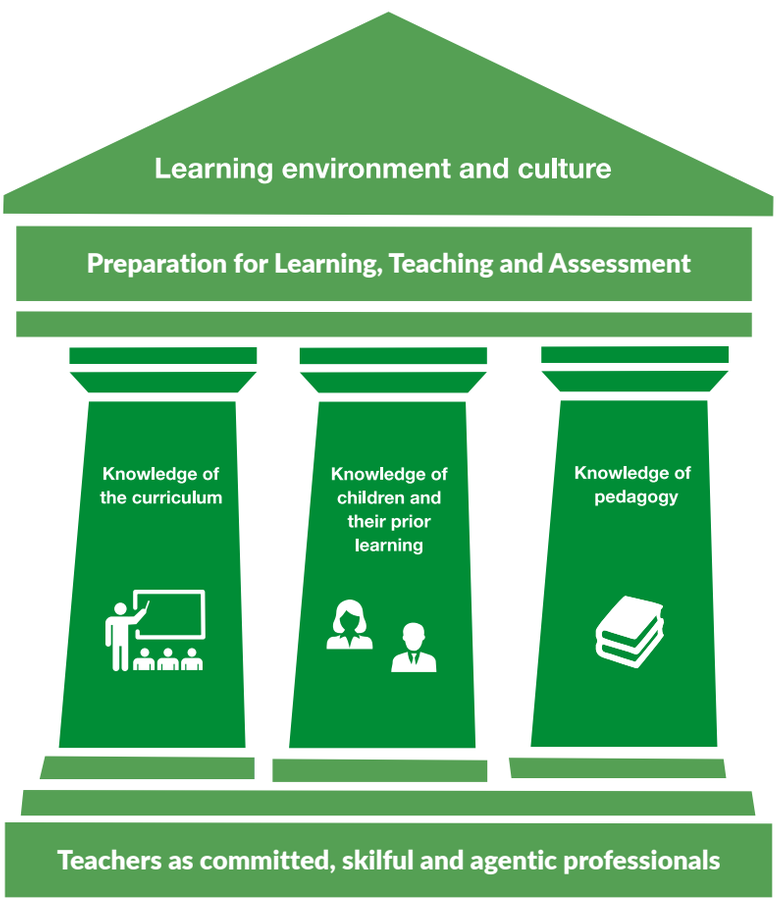


Figure 3: Teacher preparation

Regardless of the entry point, selected Learning Outcomes as well as knowledge of the curriculum anchor preparation and ensure alignment with the curriculum.

Learner entry points

- Children's questions, wonderings, observations and lines of inquiry
- A theme or topic linked to children's interests and prior learning
- Identified needs, areas for development or strengths in learning suggested by assessment information

Curriculum entry points

- The Learning Outcomes of the specifications
- The key competencies of the curriculum

Contextual entry points

- A local, national or international event or topical issue
- An engaging Learning Experience observed or shared by a fellow teacher or through professional learning
- Spontaneous teaching opportunities (e.g., first signs of spring, fixing broken equipment or testing new school technologies)

Learning Outcomes support preparation that enables every child to learn and develop. In the main, they describe the expected learning and development at the end of each stage (a two-year period). They are designed to be broad and flexible to support progression in learning for every child. Ongoing, high-quality assessment plays a central role in identifying each child's abilities, strengths, needs and next steps in learning, ensuring that decisions about the most appropriate Learning Outcomes are responsive, evidence-informed and focused on supporting meaningful progression.

It is expected that children work towards all of the Learning Outcomes for their stage. However, for some children, it may be appropriate, in particular curriculum areas and subjects, to work towards Learning Outcomes or aspects of Learning Outcomes from a different stage. These decisions should be based on knowledge of the children informed by assessment information and reviewed regularly. Longer term measures, where a child continues to work towards Learning Outcomes from a different stage, for an extended period, should be taken in consultation with the special education teacher (if applicable). This should be supported by a strong evidence base, be reflected in the child's *Student Support Plan* (SSP) in consultation with parents and reviewed regularly.

To support coherence and progression in learning and to avoid unnecessary repetition or gaps in learning opportunities, schools should consider the sequencing of learning across each stage through whole-school planning and ongoing teacher collaboration. Children will progress at different rates. Progression includes periods of new learning, practice and consolidation, and therefore every outcome, or every aspect of an outcome, may not need to be addressed each year. What is important is that, across the two-year stage, Learning Outcomes are intentionally prepared for, revisited as appropriate, and used to support children's progress towards expected learning. Across all contexts, the aim is to ensure that every child experiences meaningful progression in their learning and is supported to work towards the Learning Outcomes of the curriculum.

In STE, the Learning Outcomes are underpinned by skills (e.g., questioning, testing and pattern spotting), processes (e.g., scientific inquiry, design thinking and computational thinking), and concepts (e.g., life cycles, the properties of materials, forces and digital systems).

Examples of concepts, processes and skill development within STE Learning Outcomes include:

- At Stage 2 of the *Materials* strand, children learn about the properties of materials (concepts), conducting inquiries (processes) and how to ask testable questions (skills)
- At Stage 3 of the *Technology* strand, children learn about how technologies function and develop (concepts), computational thinking (processes) and debugging (skills).

In parallel with assessment information, consideration of the use of Additional Support Pathways (ASPs) in Chapter 6 may assist a teacher in identifying appropriate and meaningful entry points to support children's learning and in creating inclusive Learning Experiences for every child. ASPs are a tool designed to support more individualised learning for children with SEN. They outline different ways children might engage with or demonstrate progression towards Learning Outcomes.

Considerations for Whole-School Curriculum Planning

Schools can:

- plan for and promote progression and continuity through the gradual building of knowledge, skills, concepts, dispositions, attitudes, and values in STE Education
- use assessment information to support the continuity of the children's STE Education learning as they progress through the school.




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Focus(es) of Learning

In working with the Learning Outcomes in the *STE Education* specification, a teacher should identify a clear Focus(es) of Learning which includes the knowledge, skills, concepts, dispositions, attitudes and/or values that children will learn or develop next. Drawing on their knowledge of the children and their prior learning, together with their knowledge of the curriculum and knowledge of pedagogy and assessment, teachers identify the most appropriate focus(es).

There may be more than one Focus of Learning within a Learning Experience. The Focus(es) of Learning may include new learning, consolidation of prior learning, or both. In identifying the Focus(es) of Learning, a single Learning Outcome or aspects of more than one Learning Outcome may be selected from within and across specifications, facilitating integration where meaningful and appropriate. In a teacher's short-term preparation, they may record the Focus(es) of Learning in their own words, ensuring it is drawn from the relevant Learning Outcome(s). Assessment should provide opportunities for children to reflect meaningfully and demonstrate their learning in ways that are aligned with the Focus(es) of Learning.

Teachers are best placed, given their knowledge of the children in their bespoke context, to identify a Focus(es) of Learning that supports children to work towards Learning Outcomes. When identifying a Focus(es) of Learning teachers consider:

- The children and their prior learning (what they know, understand or can do now) as identified through assessment information
- Next steps in progression (for example, as exemplified in Toolkit progression supports).

While many STE concepts, skills and processes naturally overlap, teachers may wish to plan for the development of certain concepts, skills and processes as a particular focus within a Learning Experience. Examples include:

- conducting scientific inquiries with a focus on drawing conclusions and presenting findings
- gathering data sets, with a focus on learning *about* data or interpreting the data
- designing for a 'client' with a focus on user need or evaluating a prototype.

Learning Experiences

Once a teacher has identified the Focus(es) of Learning, a range of appropriately playful and engaging Learning Experiences should bring the focus(es) to life. These experiences encompass what the children will do, will engage in, will experience, will create, etc., as they work towards the Focus(es) of Learning. Through their knowledge of the children, the curriculum and pedagogy, teachers prepare for the Learning Experiences.

When preparing for the Learning Experiences, it is important that they:

- Reflect the children's prior learning, abilities, interests and needs
- Support inclusion and meaningful learning
- Are enhanced by pedagogical approaches and the Elements of the *STE Education* specification
- Provide meaningful and engaging opportunities for all children to actively respond to, demonstrate, contribute to, reflect on, record and apply their learning.

While Learning Outcomes, Focus(es) of Learning and Learning Experiences each play a distinct role in teachers' preparation, they are interconnected so that the children's learning is purposeful.

The following example illustrates how a teacher may prepare for a Focus(es) of Learning and Learning Experience in STE Education.

This sample content is illustrative only, to demonstrate connections between the Learning Outcomes, Focus(es) of Learning and Learning Experiences.

It is not intended as an example of a teacher's recorded preparation.

Stage 2 – Science – Materials		
Learner entry point: During an Engineering Learning Experience, a teacher noticed that children's planning skills could benefit from further development. This insight was used as a valuable entry point and informed the Focus(es) of Learning/Focus(es) of Assessment in the next Learning Experience involving procedural understanding (as outlined in the following example).		
Learning Outcome *Through appropriately playful and engaging learning experiences, children should be able to:*	**Sample Focus(es) of Learning**	**Sample Learning Experiences**
plan, conduct and record scientific inquiries on how materials are affected by changes in temperature, composition and weathering. AL, C, M	Developing the children's scientific inquiry planning skills. Focusing on: • increased detail in plans • paying more attention to the sequence of steps in planning • identifying in the plans how results will be collected.	The children plan for an investigation on: *'How are materials affected by changes in temperature?'* The inquiry takes place over two days; planning the investigation takes place on the first day and they conduct the investigation on day 2. The children decide to observe the effect of a hairdryer on butter, ice and chocolate. The children begin their planning. The teacher encourages the children to choose a testable question (e.g., Do butter, ice and chocolate melt at the same rate?) and asks them to sequence the steps of their investigations. Increased planning detail is encouraged through teacher questioning e.g., • *Have you recorded your predictions?* • *Is there a step-by-step account of what will take place recorded in your plan?* • *What materials do you need?* • *How will you keep the ice from melting* • *before the inquiry?* • *If the materials in the investigation are going to change, what should be kept the same in the test? (e.g., the amount of butter, ice and chocolate being tested should be kept the same, the length of time the materials are exposed to the hairdryer and the heat level must be kept consistent)* • *How will you measure and record your results (e.g., by recorded observations, photographs or video)?* • *How will you present your results (e.g., oral presentation, photograph display or an entry in their STEM journals)?*

Table 1: Identifying a Focus(es) of Learning and Learning Experiences

STE Skills

The development of STE skills gives children the opportunity to draw on authentic ways of working in STEM. These skills may be taught in a range of ways, for example, they can be taught explicitly or in addition to specific content knowledge. STE skills can also be taught through integrated STEM Learning Experiences. Focusing on a skill draws children's attention to the skill, supports children in recognising its importance and enables consistent reference to the skill as it is further developed over time.

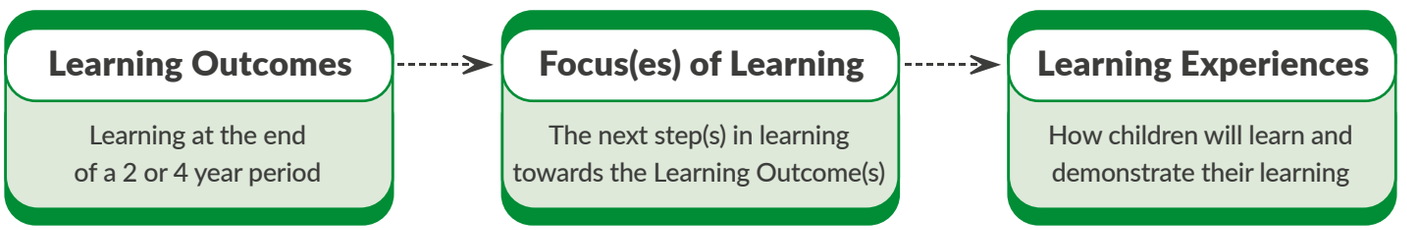


Figure 4: Learning Outcomes, Focus(es) of Learning and Learning Experiences

Considerations for Whole-School Curriculum Planning

Schools can:

- establish agreed approaches in STE Education while supporting teachers to exercise professional judgement in responding to children's needs, interests and context
- develop shared understandings of how Key Competencies are fostered through STE Education
- develop a shared understanding of the use of the Additional Support Pathways to create inclusive Learning Experiences in STE Education
- use assessment information to support the continuity of the children's learning as they progress through the school.

Organising time

The *Primary Curriculum Framework* provides the suggested time allocations to assist teachers and schools in their work with the curriculum. They are intended to be used flexibly as teachers prepare rich Learning Experiences and respond to the learning needs of children over the course of a month (based on a period of four weeks). They comprise two categories: Minimum Curriculum Time and Flexible Time. The minimum suggested monthly time allocation for STE Education is outlined in Table 2.

Stage	Suggested minimum time allocations
Stage 1	3 hours 20 minutes per month
Stage 2	4 hours per month
Stage 3	5 hours per month
Stage 4	5 hours per month

Table 2: Suggested Monthly Minimum Time Allocations for STE Education

There are natural connections across the five curriculum areas. These connections can be used to meaningfully integrate Learning Outcomes, resulting in time being used more efficiently, while also supporting learning, teaching and assessment in more than one curriculum area. Integration across the curriculum areas offers flexible approaches to working with time allocations. For example, when a class explores a Science topic within a Drama lesson and equal emphasis is given to Learning Outcomes in both Science and Drama, instructional time may be drawn from both STE Education and Arts Education.

Please see guidance on the use of time for *An Approach to Integrated STEM Learning* on p. 55 of this document.

Considerations for Whole-School Curriculum Planning

Schools can:

- agree a whole-school approach to the monthly allocation of time in STE to support proportional attention to all six strands of the *STE Education* specification.


Is the biggest magnet the strongest magnet?

Strands in the *Science, Technology and Engineering Education* specification

Science, Technology and Engineering Education (STE) is organised into six curriculum strands:

- Nature of STEM
- Living things
- Materials
- Energy and forces
- Technology
- Engineering.

Making connections across strands

In STE Education, natural connections between Learning Outcomes across strands are likely to emerge. For example, children learning about simple machines in Energy *and* forces (Stage 3) may naturally ask questions about machines from the past or what machines might be like in the future, covering aspects of the *Nature of STEM* strand. Where possible, teachers are encouraged to anticipate these connections and incorporate them into their preparation to support more coherent and meaningful learning.

Nature of STEM

The *Nature of STEM* strand consists of one Learning Outcome per stage. The strand provides an opportunity for children to explore features of the 'bigger picture' of STEM, by offering them greater insight into how STEM works in the world and how learning in STEM connects with real-world issues. In addition to existing STEM ideas, *Nature of STEM* also gives the children agency to explore, question and investigate new developments in Science, Technology, Engineering and Mathematics, keeping the children's learning current and relevant.

Teachers are encouraged to draw children's attention to features of the *Nature of STEM* whenever they engage in STEM Learning Experiences. Through continually building an understanding of the nature of STEM, children can develop and deepen their STEM literacy and appreciation for how STEM contributes to our lives and the wider world.

The following prompts may help teachers plan Learning Experiences in *Nature of STEM*. They aim to support meaningful, balanced and developmentally appropriate engagement with the Learning Outcomes:

Are there topics or questions from children's real-life experiences that could enrich and focus their learning on *Nature of STEM*?

- For example, if the children are particularly interested in some aspect of technology/sport/toys etc., the teacher may encourage them to examine how this interest relates to STEM. They could look at how a related object/design has evolved over time and how it might evolve in the future. If they choose something that has made an impact on society, it is important to highlight how STEM and society are intrinsically linked.

How will children have opportunities to engage in explicit, hands-on learning on the *Nature of STEM*?

- Opportunities for learning about *Nature of STEM* will naturally occur as children work towards other Learning Outcomes in the *STE Education* specification. However, children may also benefit from explicit Learning Experiences focused solely on the Learning Outcomes in this strand. For example, at Stage 2, teachers could bring children to different learning environments to specifically develop their 'STEM eyes'. At Stage 4, during a hands-on Design thinking Learning Experience, features of the Nature of Engineering may be addressed, such as how engineers may have to alter design plans due to constraints such as limited time or the availability of materials.



How can *Nature of STEM* be taught in combination with another strand(s)?

- *Nature of STEM* presents a viable option for meaningful integration with all of the other strands in the specification. It aims to make the children's learning in STE Education relevant to their lives. For example, if children are tasked with designing a digital application ('app') to help a senior citizen, they could also consider the responsibility of designing technology (Nature of Technology) to make sure their design does not pose any risks.

Are specific resources/equipment needed to support *Nature of STEM* Learning Outcomes?

Examples of resources that could support learning and teaching about the *Nature of STEM* include:

- Storybooks, books, newspapers and websites based on STEM themes such as problem solving, investigating, the history of STEM, STEM and society, etc.
- A range of hands-on materials for investigating, designing and everyday materials for fixing problems
- Access to a range of indoor and outdoor environments to practice using 'STEM eyes'
- Photographs, pictures and objects representing both old and new designs and technologies
- Technology: examples of digital technologies e.g., tablets, laptops and cameras and non-digital technologies e.g., paper clips, bicycles and wheelbarrows
- Black box activities, unplugged activities, design for a 'client' activities.

Science strands

The strands *Living things*, *Materials* and *Energy and forces* comprise the Science component of the *STE Education* specification. Across these strands, Learning Outcomes are best supported through Learning Experiences centred around scientific exploration and inquiry that spark curiosity and creativity, invite critical thinking and make meaningful connections with the biological, material and physical worlds.

At times, it may be useful to explicitly teach a specific concept or skill before or during an inquiry to ensure the children have the foundational knowledge and skills to carry out the inquiry and to enrich the Learning Experience. For example, before beginning an inquiry on dissolving, the teacher may give the children the opportunity to observe a sugar cube in water. This would support children's understanding of the concept of dissolving and ensure they can utilise the skills of predicting and observing.

For Learning Experiences in Science, children can be encouraged to use their agency and engage in mirroring the authentic practices of scientists, as they decide on scientific questions to investigate and how inquiries can be conducted.

Living things

The following prompts may help teachers to plan Learning Experiences in *Living things*. They aim to support meaningful, balanced and developmentally appropriate engagement with the Learning Outcomes:

Are there topics or questions from children's real-life experiences that could enrich and focus their learning about *Living things*?

- For example, is there a specific plant or animal the children are interested in investigating? Are the children interested in researching a particular human system or a particular aspect of their local ecosystem?

What is a key first step for children's engagement in scientific inquiries on *Living things*?

- By learning to ask testable questions about *Living things*, children can then design and conduct an inquiry to try to answer these questions. Examples of testable questions for *Living things*, across Stages 1 – 4 include:
  - Stage 1: Can plants grow without water/light?
  - Stage 2: How do local trees change throughout the school year? (Track a tree)
  - Stage 3: What factors affect heart rates? / How does a minute of rigorous exercise change pulse patterns?
  - Stage 4: Does planting more flowers increase the number of bees/pollinators in the school garden?

How do Learning Experiences in *Living things* encourage both hands-on and minds-on engagement?

When children conduct scientific inquiries, they are encouraged to engage in both hands-on and minds-on learning simultaneously. For example:

- Children can engage in hands-on learning by investigating Living things outdoors and using science resources such as pooters and magnifiers.
- Minds-on learning can include activities like posing questions about plants and animals, designing investigations, interpreting data and reflecting on their learning. Thought-provoking questions such as "*What do your results mean?*", "*Is there a different way of proceeding?*", or "*Do you need to change or modify your investigation plan?*" can help promote children's deeper thinking in science.

How can the school grounds or local environment enhance children's learning about *Living things*?

- It is encouraged that investigating living things, especially plants and animals, take place outdoors when possible. Outdoor learning provides children with first-hand experiences of nature, supports the development of authentic inquiry skills, and offers opportunities to build and apply vocabulary related to the living world in meaningful contexts.

Are specific resources/equipment needed to support *Living things* Learning Outcomes?

- Examples of equipment that may support children's learning about Living things include magnifying glasses, seeds, observation boxes, clipboards, measuring equipment, bug hotels, cameras, tablets, identifying guides, microscopes, thermometers and gloves.

How can *Living things* be taught in combination with another strand?

- *Living things* can be integrated with all the other STE strands. For example, designing a home for a small animal (*Engineering*) or using a small programmable device to facilitate a sensor to trigger when a bird is in its nest (*Technology*).

Materials

The following prompts may help teachers to plan a nd prepare for Learning Experiences for the *Materials* strand. They aim to support meaningful, balanced and developmentally appropriate engagement with the Learning Outcomes:

Are there topics or questions from children's real-life experiences that could enrich and focus their learning about *Materials*?

- For example, can a hurley/frisbee be made from a different material or what is the best material to mend an item of clothing or a broken toy?

What is a key first step for children's engagement in scientific inquiries on *Materials*?

- By learning to ask testable questions about Materials, children can then design and conduct an inquiry to try to answer these questions. Examples of testable questions for *Materials* across Stages 1 – 4 include:
  - Stage 1: Which materials are waterproof/keep water out?
  - Stage 2: What is the most suitable material to make a strong handle for a bucket? What materials are strong but light?
  - Stage 3: Do all liquids freeze the same way? What effects does heat/cooking have on a range of foods and are the changes reversible? What is the most efficient way of melting chocolate?
  - Stage 4: Does the temperature of water affect how fast sugar/salt/jelly dissolves? Can we discover/create a new material?

How do Learning Experiences in *Materials* support both hands-on and minds-on engagement?

When children conduct scientific inquiries, they are encouraged to engage in both hands-on and minds-on learning simultaneously. For example: If children are conducting inquiries into the suitability of materials for different purposes (Stage 2):

- Hands-on learning may involve physically manipulating a range of materials and carrying out an investigation
- Minds-on learning may include a range of opportunities for children to use their agency, for example, asking testable questions about materials, deciding how to investigate a question, determining whether/how data needs to be collected, identifying a method for recording results, and selecting the most suitable way to present their findings.

How can the school grounds or local environment enrich learning about *Materials*?

- School grounds and the local environment provide for first-hand exploration and investigation of materials, giving children the opportunity to connect their learning to science in their immediate environment. For example, as a way of developing their 'STEM eyes', children could engage in an outdoor material hunt and investigate, as far as possible, the properties of interesting/unusual materials or natural and non-natural materials.

Are specific resources/equipment needed to support *Materials* Learning Outcomes?

- Examples of equipment required include samples of common, natural, synthetic and manufactured materials. Equipment for heating and cooling materials is required in Stage 3. Specific resources such as food samples may be needed and should only be organised by the teacher, considering risks such as food allergies.

How can *Materials* be taught in combination with another strand?

- *Materials* can be taught in combination with all the other STE strands. For example, a Stage 3 Learning Experience on plastics can be taught in combination with the *Nature of STEM* by learning about the positive and negative impact plastics have made on society.

Energy and forces

The following prompts may help teachers plan Learning Experiences for the *Energy and forces* strand. They aim to support meaningful, balanced and developmentally appropriate engagement with the Learning Outcomes:

Are there topics or questions from children's real-life experiences that could enrich and focus their learning on *Energy and forces*?

- For example, exploring how *energy and forces* allow simple machines to work (e.g., how a pedal bin, toy car, seesaw or a magnetic game works), or how a fork can appear broken in a glass of water (refraction).

What is a key first step for children's engagement in scientific inquiries on *Energy and forces*?

- By learning to ask testable questions about *Energy and forces*, children can then design and conduct an inquiry to try to answer these questions. Examples of testable questions for *Energy and forces* across Stages 1 – 4 include:
  - Stage 1: Will a heavy object always sink?
  - Stage 2: What is the best material to insulate sound? What techniques affect the kick (force) of a football?
  - Stage 3: What is the fastest speed a toy car can reach?
  - Stage 4: Does the length of the wire affect how bright the bulb shines in a circuit? How does an electrical circuit switch work and can one be made with everyday materials?

How can Learning Experiences in *Energy and forces* support both hands-on and minds-on engagement?

When children conduct scientific inquiries, they are encouraged to engage in both hands-on and minds-on learning simultaneously. For example, if children are conducting inquiries into aspects of magnetism, sound, light, electricity or forces:

- Hands-on learning may involve physically manipulating a range of materials and carrying out an investigation. Handling and using equipment such as magnets, string telephones, prisms, electrical circuits, ramps, carts and swings gives children an opportunity to construct a deeper understanding of what *energy and forces* are and how they work
- Minds-on learning may include a range of opportunities for children to use their agency, for example, by asking testable questions, deciding how to investigate a question, determining how to collect evidence and results or by drawing conclusions and selecting the most suitable way to communicate their findings.

How can the school grounds or local environment enrich learning about *Energy and forces*?

- The school grounds or local environment provide options for children to explore Energy and forces in meaningful and authentic contexts. Learning Experiences in the outdoors including, for example, floating and sinking, pushing and pulling, moving forces, testing simple machines, investigating light, friction and gravity can offer playful learning opportunities with real-world investigation and testing, genuine unpredictability and immediate feedback.

Are specific resources/equipment needed to support *Energy and forces* Learning Experiences?

- Specific equipment will be needed for Magnets (Stage 1), Sound (Stage 2), Light (Stage 3) and Electricity (Stage 4). A range of resources will be needed to investigate different forces, e.g., toy cars, elastic bands, ramps, a stopwatch, measuring tools, scales, water containers, pulleys, string and balls of different sizes and weights.

How can *Energy and forces* be taught in combination with another strand?

- *Energy and forces* can combine all STE strands. For example, with *Engineering* and/or *Technology*, children may be asked to design and build a marble run, investigating different types of energy and gravity and using computational thinking to decompose the design into loops, turns and jumps. A prototype may be physically engineered, or a simulation of the marble run could be created on a digital platform.

Technology

Technology Learning Outcomes are best supported through Learning Experiences centred around supporting children in understanding technology, using technology and creating with technology. *Technology* Learning Experiences should engage children in ways to facilitate creative and critical thinking and build a range of technological and problem-solving skills.

At times, it may be useful to explicitly teach a specific concept or skill before or during a computational thinking Learning Experience to ensure the children have the foundational knowledge and skills to carry out the challenge and to enrich the Learning Experience. For example, before teaching a data-driven challenge, teachers may choose to explicitly teach an aspect of data handling such as collecting or interpreting a data set.

Children can use and develop their agency in computational thinking Learning Experiences by making decisions regarding how to decompose problems, abstract information, identify patterns and write and refine algorithms.

The following prompts may help teachers plan Learning Experiences for the *Technology* strand. They aim to support meaningful, balanced and developmentally appropriate engagement with the Learning Outcomes:

Are there topics or questions from children's real-life experiences that could enrich and focus their learning on *Technology*?

- For example, children may identify, question, explore and investigate technologies they use in daily life, at home, in the classroom or through sport or in the community.

How can *Technology* Learning Experiences promote a balanced understanding of technology?

- For example, by supporting children to develop a broad understanding of technology means showing them that technology includes everyday tools such as scissors and clothes pegs (tools to meet practical, real-life needs), as well as digital devices. Children can explore the purpose, functions, benefits and potential drawbacks of both digital and non-digital technologies. This helps develop their critical thinking and digital literacy.

How can Learning Experiences in *Technology* support both hands-on and minds-on engagement?

When children are using technology or learning to understand aspects of technology and creating with technology, they engage in both hands-on and minds-on learning simultaneously. For example,

- Hands-on learning may involve a Learning Experience such as creating a digital story which involves practical skills (e.g., navigating a device, editing audio or video)
- Minds-on learning in *Technology* includes critical thinking while decomposing problems, creating algorithms and communicating ideas.

How can the school grounds or local environment enrich learning about *Technology*?

- Outdoor settings can connect classroom learning to real-life contexts. For example, children can use digital devices such as tablets, data loggers, map applications ('apps'), mechanical tools such as gardening tools, a rain gauge or a compass to explore how they impact or can be applied in settings outside of the classroom.

How can unplugged (non-digital) activities support children's computational thinking skills?

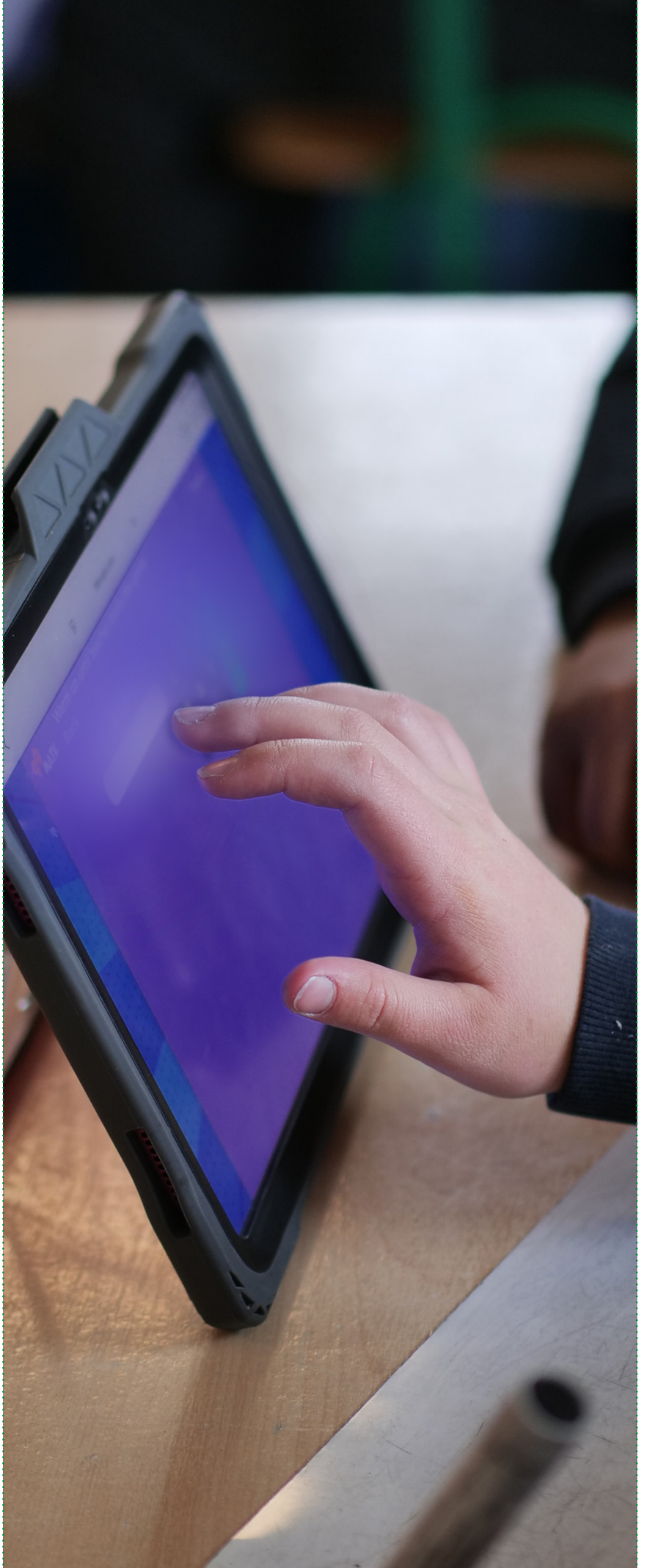
- Unplugged activities provide opportunities for children to explore computational thinking skills such as sequencing, creating and identifying patterns and writing simple algorithms through playful, hands-on and physical experiences. After completing unplugged tasks, it is encouraged that children are given opportunities to apply the same skills using digital devices, making explicit connections between unplugged and plugged Learning Experiences.
  Examples of unplugged and plugged activities include:
  - Unplugged: Create an algorithm using a real-life sequence (e.g., baking a cake or giving directions)
  - Plugged: Program a physical or virtual device to follow a course using a sequence of instructions.

How can children's safe and responsible use of technology be supported?

- School policies should be always followed regarding the use of technology. Clear, age-appropriate technology guidance should be established and shared with the children—especially when using the internet or online tools. (See Media and Digital Wellbeing Learning Outcomes, *Wellbeing* specification, p.28).

How can *Technology* Learning Outcomes be integrated with other STE strands?

- *Technology* can be combined with all STE strands. For example, the teacher could encourage the children to use a 3D design application ('app') to plan and design a model in *Engineering*, connecting digital design with spatial awareness and problem-solving. Data loggers can be used to record variables when investigating aspects of *Energy and forces*, such as light or sound.



Engineering

In the *Engineering* strand, the Learning Outcomes are grounded in the Design thinking process. These Learning Outcomes are best supported through Learning Experiences centred around open-ended design problems or challenges that spark curiosity, invite creativity and encourage problem-solving.

Children engage in empathising, prototyping, testing, and reflecting as they work through the design process to design something novel or improve on an existing design.

A wide variety of approaches may be used to generate meaningful and age-appropriate design problems.

The following prompts are intended to support meaningful, balanced, and developmentally appropriate engagement with the Learning Outcomes as teachers plan Learning Experiences in *Engineering*:

Is there a topic or question from children's real-life experiences that could inspire a Design thinking challenge?

- Real-world school, home and community-based challenges, such as designing something that is needed to solve a local problem or redesigning a broken object, enriches the authenticity of children's learning in *Engineering*. For example, a dirty floor in the local hall could lead to the design of a simple machine for cleaning the children's muddy shoes or a child's broken umbrella could spark an investigation and redesign.

How can the school grounds or the local environment spark Design thinking problems?

- Children may be presented with opportunities to design a ramp for school use or an accessible slide for a nearby playground. They could be tasked with improving the design of school chairs or designing a bespoke classroom storage unit.

How can solving a design problem draw on prior learning in Science, Technology or Mathematics?

- For example, children might apply prior learning to select suitable materials for a design task. They could analyse a range of materials (Science) and choose the most appropriate for designing, for example, a shelter for a pet/small animal or a boat/raft (*Technology*) to carry a specific weight (Mathematics).

How can design ideas emerge from other areas of the curriculum?

- A design-focused Learning Experience may emerge from a music Learning Experience (e.g., designing a new type of musical instrument) or a PE Learning Experience (e.g., designing equipment for a new crazy golf game).

Can Design thinking challenges emerge in other ways?

- Design challenges can be generated by identifying a user, or an engineering 'client', such as a person/group of people, a puppet or a fictional character who has/have user needs and would benefit from a new design or an improvement of a design to solve a problem, for example, a teddy bears' picnic could lead to designing a chair for teddy, or local farmers might need a more effective scarecrow to protect their crops
- Fairytales, picture books, and non-fiction texts can also present scenarios that can also be reimagined as engaging design challenges.

How can *Engineering* Learning Outcomes be integrated with other STE strands?

- *Engineering* can be integrated with all the other STE strands. For example, designing earmuffs for a fictional character who can't sleep at night can be linked to sound in *Energy and forces* or designing a mechanical treat dispenser for a pet can be linked to *Living things*.



Integration

Integrated learning, both within and across curriculum areas and subjects, is an important part of the curriculum. It helps children see connections between ideas, deepen their understanding and apply knowledge, skills, concepts, dispositions, attitudes and values in real-world contexts. There are multiple approaches to effective preparation for integration. Below are some suggestions to help guide teachers' preparation and make integration meaningful and engaging for children's learning.

No matter where a teacher starts, they should always ask – *Will this be authentic and purposeful for the children in my class and does it offer the potential for meaningful learning?*

As a teacher prepares for integrated Learning Experiences, consideration may be given to:

- **Agency:** How have the children's interests, strengths, questions and choices as well as the teacher's professional judgement shaped the focus(es) and resources used?
- **Relevance:** Does an integrated approach reflect the children's abilities, interests and needs in the curriculum areas or subjects being integrated?
- **Learning Outcomes:** Which specific Learning Outcomes will be addressed across the curriculum areas and subjects being integrated?
- **Focus(es) of Learning and Learning Experiences:** What is the Focus(es) of Learning and how will playful and engaging Learning Experiences support this Focus(es) of Learning?
- **Duration:** Is this a unit of integrated learning over several weeks, or a shorter integrated Learning Experience?
- **Time and balance:** How is time allocated across subjects and will one curriculum area or subject lead or be emphasised more?
- **Assessment:** How will the teacher know what children have learned or experienced and also identify the next steps in learning in the respective curriculum areas/subjects?

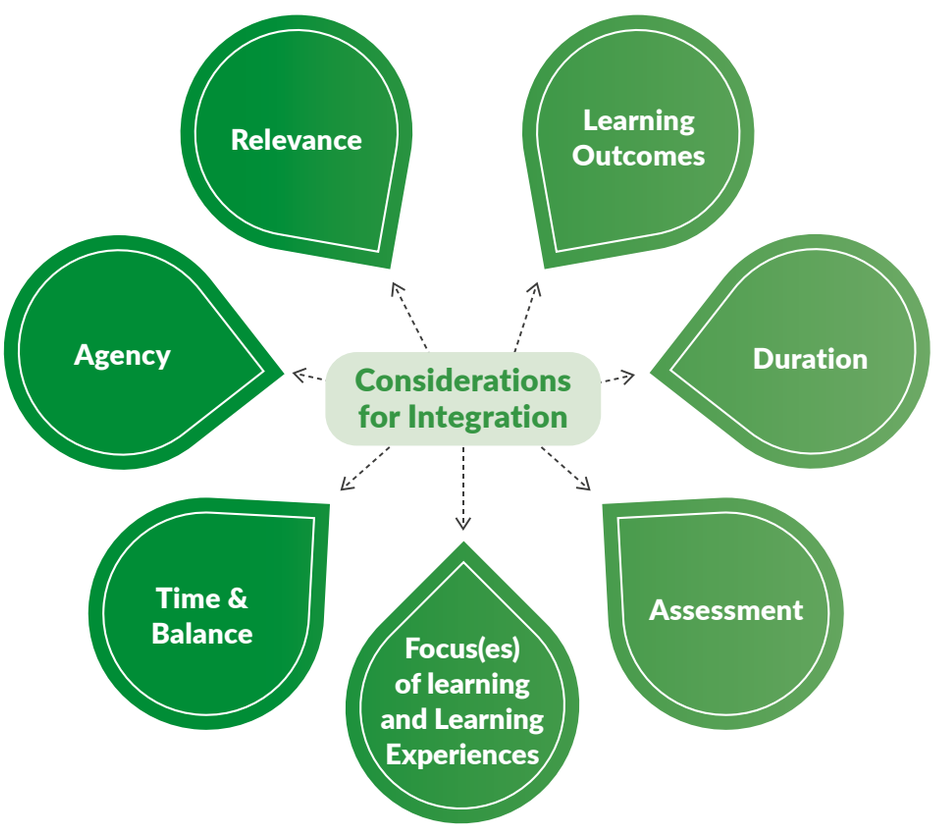


Figure 5: Considerations for Integration

When preparing for successful integration:

- Start with meaningful links – avoid forcing connections or the 'tokenistic' inclusion of curriculum areas or subjects
- Keep the integrity of each curriculum area or subject by ensuring that each one is clearly addressed through the Focus(es) of Learning
- Embrace spontaneous opportunities when they arise.

Teachers should prepare for STE Education Learning Experiences that involve integration within the curriculum area itself. Table 3 presents a non-exhaustive set of examples of integration within STE. It is not intended as an example of a teacher's recorded preparation. The samples used have been chosen by way of illustration only.

Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	**Sample Focus(es) of Learning**	**Sample Learning Experiences**
Stage 1 **Strand:** Engineering explore real and imagined design problems that are relevant to their lives. Communicate and share ideas about how these design problems might be solved. Plan and make a simple prototype to solve a design problem and reflect on the process they undertook. AL, C, CL **Science** **Strand:** Materials explore a range of common materials found indoors and outdoors. Identify the main properties of these materials, what they are made of and the ways they can be used in different contexts. AL, CL **Science** **Strand:** Energy and forces develop the skill of predicting through investigating the effect that magnets have on different materials. Discuss everyday uses of magnets. AL, CL	Planning and developing a prototype. Identifying the magnetic properties of materials. Developing the skill of predicting and an understanding of the effect that magnets have on different materials.	The children are encouraged to explore a range of common materials, predict which materials are magnetic, test the materials and sort the materials into magnetic and non-magnetic materials. The children design a magnet fishing game for a group of friends to play. They explore how to make the fishing rod, how to attach the magnet and how the game will work. The children make a basic prototype of the game.

Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
Stage 2 **Strand:** Nature of STEM develop their 'STEM eyes' by exploring their immediate environment (home, school, play areas) and everyday objects through a STEM perspective. AL, DL, M **Strand:** Technology explore and use a range of common digital and non-digital technologies. Consider how these technologies work and what purposes they serve in people's lives. AL, DL, W	Identifying Science, Technology, Engineering, Mathematics and STEM in the school environment. Identifying the function and purpose of digital and non-digital technologies.	The children are encouraged to explore a learning environment (e.g., a room in the school, the school hall, the school yard) with 'STEM eyes'. The teacher prompts the children to consider scientific and mathematical questions such as – *What living and non-living things can we identify? What materials can be found? Can we find any natural patterns in this environment?* They consider technology and engineering questions such as – *Are there features of the environment that have been designed i.e. benches, gates, climbing frames? Could we improve on those designs? Are there plugged or mechanical technologies in the environment and what is/are their purpose(s)?* The children record examples of digital and non-digital technologies (lists, symbols, photos or drawings). Where possible, they explore how some of the technologies function and the purposes they serve in people's lives.
Stage 3 **Mathematics** **Strand:** Shape and Space **Strand Unit:** Shape represent shapes with drawings and models, and calculate dimensions of shapes. **Strand: Engineering** use empathy to consider user-needs, risks and limitations when identifying and researching design problems. Systematically plan, make, test and evaluate a design prototype to solve at least one of these problems. Make iterations and improvements based on reflections and peer feedback. AL, C, CL	Exploring and representing the circle and the cylinder. Prototyping, testing and iterating a design.	The teacher introduces the children to a new engineering 'client' – The Hamster (a hamster photo will suffice). They hear a story about the hamster, outlining that the animal sits quietly in the corner every day because it has nothing to play with (encouraging empathy). The children are tasked with designing a sturdy hamster wheel. Plans should include drawings with detail and mathematical dimensions, considering the user's needs. The children learn about the circle (mathematics) and the axle for the wheel (science-simple machines).

Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
Science **Strand:** Energy and forces investigate and describe how forces can cause simple machines to operate. Using fair testing, investigate how forces can cause objects to move, stop and change speed, direction or shape. AL, M	Understanding, investigating and testing what an axle is and how it works.	The children are encouraged to make, test and adjust prototypes of the hamster wheel, using the Design thinking process.
Stage 4 **Science** **Strand:** Living things identify and discuss the main systems of the human body and how they work together. Investigate how at least one human system operates. AL, CL, W	Investigating a human system and how it operates (e.g., the circulatory system or the digestive system).	Systems: The children engage in learning about a human system (e.g., circulatory system) and how it operates, followed by the exploration of a simple digital system (e.g., a calculator) and how it operates. The teacher draws the children's awareness to: • noticing the different parts of the system • connections in the systems • cause-and-effect in the systems. The children can explore faults/bugs in the systems, for example, a lack of oxygen in the circulatory system or an order of operations bug in a calculator. The children connect their learning about inputs, processes and outputs to the systems. For example: • The circulatory system takes in oxygen (input), moves oxygen and nutrients around the body (process) and helps cells release energy from food (output). • A calculator takes instructions, processes information and gives out results.
Strand: Technology identify and discuss the main components of at least one digital system and how it operates. Explore and identify the inputs, processes and outputs of this system. AL, CL, DL	Investigating a digital system and how it operates (e.g., A simple digital game or a basic calculator).	

Table 3: Examples of integration within STEM Education

Integration with other curriculum areas

Teachers should prepare for STE Education Learning Experiences that involve integration with other curriculum areas and subjects. Integrated STE Education Learning Experiences should be prepared for in parallel and should interact with other curriculum areas and subjects rather than be subsumed into them. Table 4 presents a non-exhaustive set of examples of integration across curriculum areas and subjects. It is not intended as an example of a teacher's recorded preparation. The samples used have been chosen by way of illustration only.

Integration	Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
STE Education and SEE	**Stage 3** **Strands:** Engineering, Materials, Nature of STEM **Aspects of a range of Learning Outcomes** Designing a simple machine (Engineering and Energy and forces) Properties of materials (Materials) The evolving nature of STEM (Nature of STEM). **History** **Strand:** Europe and the wider world **Strand unit:** Identity and heritage listen to and discuss a range of stories from various cultural, ethnic and religious backgrounds about people who lived in other countries. AL, CL, W	Designing a simple machine, exploring the properties of a range of materials and understanding the evolving nature of STEM. Examining and comparing similarities and differences between the past and present. Through story, determining what has stayed the same and what has changed over a period of time.	Topic: DaVinci's Parachute The children explore the drawings and story of Leonardo da Vinci – Scientist, Engineer, Artist, Architect and Inventor. They explore DaVinci's parachute design and compare it to a modern parachute, looking at structure, materials and functionality, discussing how parachutes have evolved and how they might be adapted in the future. The teacher encourages them to investigate if the type/size/weight of different materials used might change the speed of how a parachute falls. A prototype of a parachute can be designed using the information learned from the materials investigation.

Integration	Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
STE Education and Arts Education	**Stage 4** **Science** **Strand:** Energy and forces research how electricity works and conduct open-ended scientific inquiries using electric circuits. Identify and classify materials as electric conductors or insulators. AL, CL **Drama** **Strand:** Exploring and creating explore, improvise, represent and adapt ideas in a range of dramatic forms to explore and communicate complex ideas, themes, relationships and dilemmas. AL, CL, C	Understanding the electric circuit and how it works. Taking a topic and representing it clearly through dramatic form.	The children revise their understanding of how electric circuits work by connecting circuits which include bulbs, buzzers and/or motors and making switches. They use their imaginations and generate ideas that dramatise their understanding of electrical circuits. They consider and choose ideas that represent various roles for parts of the circuit (e.g. the batteries, lightbulbs, buzzers, motors, electrons and the switch). The teacher prompts the children to decide how they can portray the wire and the flow of the current throughout the circuit (e.g., stand in a big circle connected by a long piece of wool and the electron characters can move/march around the wool circuit when the circuit is connected.) They can choose to represent a role in the circuit by assigning role-signifiers or specific movements, e.g., the switch, wearing a cloak/hat can dramatise the connecting or disconnecting of the circuit by dramatically connecting the two ends of the wool through physical action. They can devise a way of demonstrating how the circuit behaves, showing the activity when the circuit is connected and stillness when it is disconnected.

Integration	Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
STE+M Education and SEE	**Stage 3** **Science** **Strand:** Materials classify materials according to their properties, state (solids, liquids and gases) and their potential impact on the environment. AC, AL, CL **Mathematics** **Strand:** Data and chance **Strand unit:** Data pose questions of interest and collect, display and critically analyse data in a range of ways for a range of purposes and communicate the findings. **Geography skills** **Investigating:** Ability to systematically explore and gather information to understand a topic or solve a problem. **Using evidence and sources:** Ability to select, evaluate and apply reliable information to support ideas or arguments. **Interpreting and analysing:** Examining information critically and drawing meaningful conclusions.	Investigating the properties of plastic and classifying different types of plastic. Collecting and analysing data. Gathering information, applying reliable information to support ideas and drawing meaningful conclusions.	Theme: Reducing plastic waste The teacher draws the children's attention to plastic waste through, photos, walks, school plastic audits, supermarket advertising, etc. They classify samples of plastic according to potential environmental impact, e.g., how long they take to decompose. Questions may be posed regarding: (1) the use and human need for the plastics (2) the materials that might be potential alternatives for plastics. Data may be collected (on a 'plastic hunt') on the use of different types of plastics in the school and the data collected may be critically analysed. Conclusions may be drawn regarding the use of plastic in the school and considered for further action(s).

Integration	Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
Key Competencies: Being creative and Being mathematical	**Stage 2** **Technology** use, modify and/or create algorithms by following a step-by-step process. Identify and recognise bugs in the algorithm and consider possible improvements. Explore how digital technologies operate according to precise instructions [specific actions in an algorithm that direct the process of solving a problem or completing a task]. AL, DL, M	Writing simple algorithms through precise instructions.	The children creatively design a bead bracelet or block tower using repeated or growing patterns with colours and/or shapes. The teacher invites them to write a simple algorithm (step by step sequence) using words and/or symbols so that a classmate can make the same bead bracelet/ block tower (without seeing the original).
	Mathematics **Strand:** Algebra **Strand unit:** Patterns, rules and relationships identify and express relationships in patterns, including growing or shrinking shape patterns and number sequences.	Growing patterns with increasing detail.	

Table 4: Examples of integration with STE Education and other curriculum areas and subjects

Not all integration can be formally prepared for or anticipated. Everyday integration and 'teachable moments' can also offer valuable and authentic opportunities for children to build connections across the curriculum. In STE Education, examples of natural and spontaneous integration include:

- when the children are designing scientific inquiries on how forces can affect the movement and motion of objects (Stage 2), teachers may spontaneously decide to move to the outdoors and integrate the learning with a PE Learning Outcome on movement skills - such as throwing, kicking and striking with the hand/enact through the PE activity area of games
- when the children are learning about how *Living things* connects to the wider field of Biology and other 'Bio' fields (Stage 4), teachers might see an immediate connection and opportunity for integration with learning about morphology (in the *Language* specification) – the study of words, how they are formed and their relationship to other words in the same language. Morphology analyses the structure of words and parts of words, such as stems, root words, prefixes and suffixes.

Considerations for Whole-School Curriculum Planning

Schools can:

- develop a shared understanding of STE Education and how Science, Technology and Engineering integrate meaningfully
- promote the development and use of disciplinary language in integrated learning to communicate, evaluate and reflect on Learning Experiences
- promote Learning Experiences that facilitate engagement with authentic, real-world STEM problems and challenges for all children.


Will my plant seed grow if I pour orange juice on it every day?

Artificial Intelligence and teacher preparation

Informed, purposeful and ethical use of Artificial Intelligence (AI) can present opportunities to augment and support teachers' preparation for learning, teaching and assessment (*e.g., aiding teachers' understanding of unfamiliar topics, generating and providing feedback on ideas for Learning Experiences or assessment approaches, etc.*). As with all digital tools in education, teachers should be aware of the limitations and risks associated with the use of AI in preparation (*e.g., misinformation, bias, hallucinations, data privacy, copyright, etc.*). Before using tools or programmes which incorporate AI, they should be reviewed for accuracy, alignment with the curriculum, pedagogical relevance and most importantly, safety and trustworthiness.

The management of educational data must be secure and protect the privacy of children, teachers and wider members of the school community. Where a decision is made to use a tool incorporating AI, teachers remain in the lead ensuring the tool supports rather than directs their professional decision-making and judgement.

There are a number of important considerations when exploring the potential use of AI tools to support teacher preparation:

- Does the tool adhere to the relevant policies and guidelines of your school? Is the tool GDPR compliant?
- Will the AI tool or programme meaningfully support teachers' preparation?
- Can you guide and shape AI outputs so they support, rather than replace, teacher professional judgement?
- Are outputs relevant and contextually appropriate to your school setting?
- Before using the output from the tool, have you checked it against other sources and adapted as appropriate?

In all instances, the teacher is responsible for overseeing the output of any AI tools used and ensuring informed, purposeful and ethical use. Further, and evolving, information on the use of AI in schools is available from the Department of Education and Youth's *Guidance on AI in Schools* and through supports provided by Oide and the National Council for Special Education (NCSE).

Parents and families

Establishing and maintaining partnerships between schools and families will enrich children's experience in STE Education. Schools are encouraged to engage in proactive communication with parents. It is important that parents are made aware of the meaningful contribution that learning in STE Education makes to their child's overall development.

A partnership approach is grounded in open, reciprocal communication where both teachers and parents play a vital role in supporting children's learning in STE Education. This approach recognises parents as their child's primary educator, with unique insights into their abilities, interests and needs. Parents' active interest in helping their children to learn and develop in STE Education is invaluable. They should be assured of the importance and impact of their contribution. It also supports parents to consolidate and extend learning at home.

Children's everyday STEM thinking often occurs through interactions with parents, for example when cooking, fixing broken items, gardening or using technology.

During preparation, teachers may choose to involve parents and families in STEM learning in a variety of ways, such as by encouraging brainstorming and discussion of testable questions, using concept cartoons, or engaging with STEM starters at home. STEM starters typically involve short, open-ended questions, problems, or challenges, where participants share ideas about possible solutions.

Parents could be encouraged to ask the children open-ended questions during play or activities that potentially lead to investigations, a new or improved design or using the computational thinking process.

Children's planning and ideas for investigations, designing and computational thinking can also be shared with parents and families, by the children themselves, to demonstrate how they are engaging with STEM learning at school.

For example, at Stage 2, when children are developing their 'STEM eyes', parents could be encouraged to draw children's awareness to Science, Technology, Engineering and Mathematics in their everyday lives. At Stage 4 when they are exploring and discussing topical STEM issues in Ireland and in the wider world, parents could be encouraged to discuss these issues with their children. These Learning Experiences lend themselves to rich conversations and collaboration between home and school.

Preparing to involve parents and families in STEM learning can help children recognise how creativity and critical thinking are enhanced through collaboration and can also expose them to a range of perspectives. The resulting ideas, discussions, and possible solutions can then be brought back into the classroom for further exploration and debate.

Considerations for Whole-School Curriculum Planning

Schools can:

- develop shared approaches for communicating with parents and families that support children's learning and strengthen connections between home and school, while recognising the diverse contexts of families
- identify opportunities to support continuity of STE learning between home and school.

Guest speakers and external facilitators

The specification is purposefully designed for enactment by teachers, as committed, skilful and agentic professionals. It is grounded on the teacher's knowledge of the children, the children's prior learning, and their professional understanding of the *Primary Curriculum Framework* and the specification.

Where a specific need is identified, external facilitators or guest speakers may play a complementary role, working in collaborative partnership with teachers to support aspects of the curriculum. Any decision to involve external providers or guest speakers should consider the progression of the children's learning and whether an external facilitator or guest speaker will meaningfully enhance this. Alignment with the specification must also be considered.

If the decision is made to work with an external facilitator or guest speaker, a collaborative approach to preparation is essential. The class teacher retains responsibility for ensuring that the Focus(es) of Learning and all Learning Experiences align with the Learning Outcomes.

External facilitators and guest speakers must work under the guidance and supervision of the class teacher, who remains present with the children at all times. Clear communication between the class teacher and external facilitator/guest speaker is vital. Where appropriate, learning developed during these experiences can be reinforced by the class teacher across other contexts and curriculum areas and subjects.

A range of external STEM Education initiatives are available for schools to engage with on an elective basis. Choosing to participate in an appropriate initiative that aligns with the curriculum and offers children a distinctive STEM Learning Experience can enhance engagement, enjoyment and interest in STEM, with the potential for a lasting impact on learning.

In line with school policy and in conjunction with the whole-school plan, schools may also elect to invite guest speakers with backgrounds in Science, Technology, Engineering, Mathematics, or STEM-related fields to share their expertise and support a specific learning focus. Such experiences can provide authentic learning opportunities and enable children to make meaningful real-world connections with their STEM learning.

Key considerations when attending external STEM initiatives and inviting STEM guests into the school include:

- How does the initiative or guest's presentation align meaningfully with the Learning Outcomes (Chapter 5) in the specification?
- Is the initiative/presentation age-appropriate?
- Is the initiative/presentation inclusive, accessible and safe for all children?

Other considerations which may be helpful include:

- Will there be opportunities for the children to engage in interactive, hands-on and minds-on learning as described in the specification?
- Will the children have opportunities to engage in scientific inquiry, design thinking, or computational thinking through the initiative?
- Will there be opportunities for children to practice STE skills and further develop key competencies?

Considerations for Whole-School Curriculum Planning

Schools can:

- develop shared approaches for engaging with guest speakers and external facilitators that ensure quality, align with the context of the school, adhere to safeguarding requirements, and enrich children's learning experiences
- consider the complementary role a guest speaker/external facilitator might have in supporting STE learning for all children, across all stages.



Resources

When preparing for STE Education, it is important to recognise that the children, the teacher and the learning environment are the primary resources. Beyond these, all other resources can be considered as tools to support children's learning and their value lies in how well they help children develop understanding, skills, and ways of thinking in STE. High-quality physical and digital resources play an important role in supporting children's learning. Children should experience a wide range of resources and are encouraged to demonstrate choice and express preference in selecting and using these, where appropriate.

The following prompts may be useful to consider when selecting resources:

- **Alignment with the specification:** Do they support children's progression in learning as described in the specification?
- **Playful and engaging learning:** Are they motivating for children and reflective of the introductory text to each Learning Outcome in Chapter 5?
- **Accessible:** Are the resources accessible to support meaningful participation for every child?
- **Inclusive:** Are they inclusive of the abilities, interests and needs of the children?
- **Flexible:** Can they be used in different ways and adapted to enact the curriculum and respond to the local school context? Do they support and encourage children's choice in selecting learning activities?
- **Practical:** Are they practical to use, store, and maintain and are they suitable for individual, group or whole-class use?

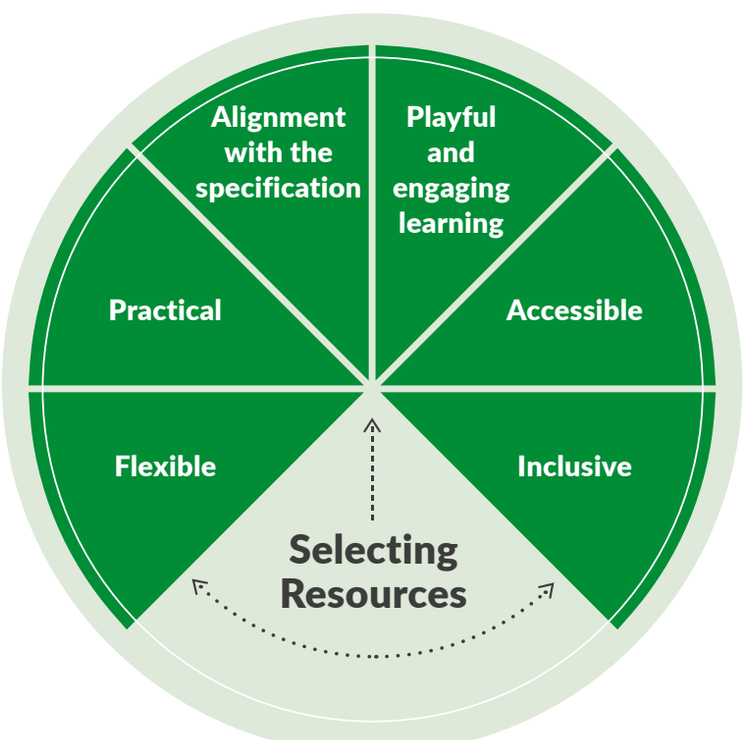


Figure 6: Selecting resources

An STE environmental audit (a structured review of the school environment and local area to discover how they can be used to support the children's learning in STE Education) and examples of useful STE resources may provide helpful support for teachers' preparation in STE.

STE environmental audit

In STE Education, resources can range from simple items such as paper clips and fabric scraps to more complex tools such as microscopes and computers, and from people to places such as factories. Often, everyday materials, including recycled or repurposed items, can be used effectively to support meaningful, hands-on STEM Learning Experiences.

Teachers may find the following reflective questions helpful when considering how indoor and outdoor spaces can support children's hands-on and minds-on STEM learning:

- Besides the classroom, are there other indoor spaces within the school that may be used for hands-on STEM activities?
- Is there an outdoor learning environment within the school grounds or local community where children can engage in STEM learning through real-world exploration?
- Are children exposed to a range of environments that help them develop their 'STEM eyes', that is, the ability to notice how STEM is embedded in everyday life? For example, in a local shop, children might observe how sensors open doors, how shelves are designed to maximise space, or how barcode scanners display prices.
- What types of trees, plants, animals, or minibeasts can children observe within the school grounds or nearby environments?
- Can children observe simple food chains or ecosystems in the local environment, for example, in a garden, pond, or park?
- What types of materials (e.g., brick, plastic, stone, slate, wood or metal) can children see or explore around the school or in the community?
- Are there examples of both digital and non-digital technologies in the school or local area? For example, is there a keypad on the school door or a lock on the gate? Are technologies (digital and non-digital) used in other areas of the school, not just the classroom? Could children imagine how these technologies might change in the future?
- Can children identify examples of engineering in the school or local area? Are there signs that older designs have been improved over time? For example, how has school furniture changed and why has it changed? How do modern playgrounds compare to older playgrounds shown in photos, particularly in terms of materials and design?
- How might the classroom environment or displays be arranged to spark curiosity and encourage further exploration of STEM ideas?

Examples of useful STE resources

Human and local resources

Teachers can draw from a diverse range of human resources and local resources, including:

- Parents: Invite parents, with links to different aspects of STEM, to share their expertise with the children.
- Community members or professionals: Invite local scientists, engineers, people working in technology and those engaging in integrated STEM to share their expertise with the children.
- Locality: Create opportunities for children to visit laboratories and local STEM industries where possible and appropriate.

STE classroom and school resources

The following prompts may support preparing for STE Learning Experiences:

- Is there an inventory of STE resources in the school?
- Are these resources organised by subject or strand?
- Are there specific STE materials aligned to particular Learning Outcomes?

For example: batteries, wires, and bulbs for electricity (Stage 4), or magnets for magnetism (Stage 1).

- Is there a supply of everyday materials to support Science inquiries and Design thinking Learning Experiences?

For example: cardboard, scissors, glue, wool and measuring tools

- What digital technology resources are available in the school? How may these be used to support children as digital learners working towards the *Technology* Learning Outcomes?
- Are interactive digital tools available?

Examples include online simulations, educational games or video conferencing platforms to facilitate external guests (such as STEM experts) for demonstrations and discussions.

- Are there both plugged (digital) and unplugged (non-digital) resources to support children's development of computational thinking?

Considerations for Whole-School Curriculum Planning

Schools can:

- plan for the provision, organisation and effective use of resources to support continuity, progression and equitable access for all children.

Programmes

Teachers and schools work with the *Primary Curriculum Framework* and the *STE Education* specification for curriculum preparation purposes. To support curriculum enactment, schools and teachers may also choose to work with programmes to guide their practice, informed by the Whole-school Curriculum Plan. While carefully selected programmes can be of benefit to children's learning in STE Education, they do not replace the *STE Education* specification or teachers' professional judgement.

At the heart of the curriculum is the child, their interests, curiosities and prior learning, and the relationships and interactions developed through rich Learning Experiences. Learning, teaching and assessment must therefore remain responsive, playful and engaging. This involves teachers adapting, modifying or supplementing any programme to ensure it aligns with the *STE Education* specification and meets the needs of the children in their unique classroom context

Programmes can support learning, teaching and assessment when they:

- are used judiciously to support breadth and balance in children's learning
- are used selectively and purposefully, rather than followed prescriptively
- allow flexibility so teachers can connect the Focus(es) of Learning with children's abilities, interests and needs
- offer opportunities for meaningful playful and engaging learning
- support the enactment of the *STE Education* specification.



Health and safety considerations

Hands-on experiences are a core component of the *STE Education* specification. Children should be provided with opportunities to use a range of tools, materials, and equipment to support learning through inquiry, design, testing, creating and building processes that are central to STE Education. As children progress through school, they should have access to, and experience of working with, an increasingly broad range of materials, tools, and devices that enable them to realise their inquiries, designs and digital creativity.

The establishment of a safe learning environment is essential when planning and organising learning in STE Education. While safety precautions cannot eliminate all risks, they should minimise unnecessary hazards. School safety policies must be adhered to at all times to ensure a secure environment for STE Learning Experiences.

Teachers have agency to design Learning Experiences that are responsive to their class and context. Consequently, it may be necessary to consider context-specific STE safety provisions. The following considerations and recommendations are intended to support good practice when preparing for STE Learning Experiences; however, they should be regarded as indicative rather than exhaustive:

- When preparing initially, teachers should reflect on health and safety considerations with the proposed STE Learning Experience. This review should consider potential risks to children in relation to the tasks, tools, materials, devices and/or learning environment(s) involved.
- Safety discussions and demonstrations should occur before activities that involve potential risks. Equipment should be appropriate to children's age and developmental stage. Where necessary, protective equipment (e.g., disposable gloves) should be used. Children should be given clear guidance on the safe obtaining, distribution, use and return of tools, materials and devices in line with school policy.
- Consideration should be given to health-related concerns, such as allergies to specific materials, e.g., parts of plants, food substances, animal hair, glue or wool.
- All adults working with the children in outdoor environments should be aware of potential hazards (e.g., working near water or traffic) and the procedures to be followed in the event of an emergency
- Preparation should include the safe, responsible and eco-conscious disposal of STE tools, materials and equipment that are depleted, damaged or expired. All tools, materials and equipment should be stored safely when not in use.

Science

While teachers cannot pre-determine the exact processes or outcomes that may emerge from open-ended scientific inquiries, ensuring that children have a sound general understanding of safety procedures and rules for the use of equipment (e.g., materials, tools, and devices) is essential for maintaining a safe learning environment.

The following outlines general safety procedures and rules. It may be useful to explicitly draw children's attention to these considerations:

Living things

- Living organisms such as plants and animals should be handled safely and responsibly, and never unnecessarily be harmed.
- Handling plants, insects, or small animals can result in allergic reactions, bites, or stings.
- Organic waste, water samples, old materials or food items can contain bacteria or mould.
- Animals and plants should only be removed from their habitat or environment when it is either unsafe or impractical to investigate in their natural settings.
- Reading local and national guidelines on working with specific/protected plants and animals.

Materials

- Hands should be washed before and after handling materials.
- Activities involving heated materials, such as hot water or cooking activities, can cause harm.
- Materials such as vinegar, baking soda, food colouring, and other common materials can cause skin irritation or eye damage if not handled properly.
- Some everyday household cleaning agents can be harmful if ingested or if they come into contact with eyes and skin.

Energy and forces

- Broken electrical equipment such as exposed wires or leaking batteries can be dangerous and should be disposed of or replaced in a safe manner.
- If improperly handled, simple electrical circuits can pose risks of shocks or short circuits.
- Low voltage batteries are more suitable for electrical circuit investigations in school.
- Water/wet hands should not be placed near electrical equipment.
- Magnets need to be stored carefully to preserve their magnetism.
- Care should be taken during work on forces, due to the risk of injury resulting from moving objects.

Technology

- Tools and devices should be carried and passed carefully e.g., scissors.
- Some technological tools and devices can be heavy, have sharp edges or electrical parts that can have risks when handled or taken apart.
- Small parts are choking hazards and should be stored safely.

Digital Technology

- The school's digital safety policies should be followed consistently to ensure a safe environment for everyone.
- Online behaviour and digital communication should be kind, appropriate and respectful (see Media and digital wellbeing Learning Outcomes, *Wellbeing* specification, p.28).
- Ergonomics and physical safety: When children are engaging with digital technologies, the furniture should be at the right height to ensure good posture.
- Digital equipment (e.g., school camera) should be used in an age or developmentally appropriate way.
- Screen time should be monitored, limited and include regular breaks
- Overloaded sockets can pose risks. All wires, plugs and devices should be monitored for overheating and risk of electrocution.

Engineering

- Sharp objects such as scissors, pins, and other tools can cause cuts and punctures.
- Practical skills such as cutting, joining, fastening, testing and building can have risks.
- Advanced tools such as junior hammers, craft knives, screwdrivers, glue guns and saws should only be used following safety guidance or training and should always be supervised by an adult.
- Machines such as object printers can generate heat and should not be touched when in operation.

A commitment to safety ensures the children can engage in STE learning with confidence and security.

Considerations for Whole-School Curriculum Planning

Schools can:

- encourage a whole-school approach to STEM health and safety
- support teachers to explicitly draw children's attention to safe practices in STE Education
- identify and consider potential hazards when exploring, investigating and engaging in hands-on STEM learning in the outdoors e.g., a local stream/river, dangerous materials or a busy road.

Glossary

Agency	Agency is the capacity to act independently and to make choices about learning and teaching.
Algorithm	An algorithm is a set of instructions and steps to create solutions to problems.
Application (i.e., digital 'app')	Digital applications (apps) are programs designed to perform specific tasks on digital devices like phones or computers. They can be used for many different purposes e.g. to learn, play, create and communicate.
Biology	Biology is the study of the living world.
Black box activities1	Black box activities facilitate children to investigate an unknown system, (e.g., a sealed box with a mechanism inside), using only observation and inference. They generate and test possible explanations (hypotheses), building representations to explain what they observe, mirroring how scientists work when evidence is limited. They are encouraged to recognise that their hypothesis, if it works, is only one possible explanation rather than a confirmed match.
Computational thinking	Computational thinking is the process that we use when considering and solving problems in such a way that computers can assist us.
Conductor	A conductor is a material/substance that allows heat or electricity to flow through it
Data	Data is a collection of information or facts, such as numbers, words, measurements, observations or other descriptions. Computer data is information in a form that can be processed by a computer.
Data loggers	Data loggers are digital devices used in STEM to automatically measure and record data over time e.g. temperature, heat or movement.
Debugging	Debugging is the process of checking and fixing errors in a program. A mistake or error in an algorithm or computer program is called a bug.
Decomposition	Decomposition involves breaking down of a problem, into several parts or components, to make the problem-solving process more manageable and efficient.
Design for a 'client' activities	Design for a 'client' activities are STEM Learning Experiences where children design solutions to meet the needs of specific users or 'clients', using the Design thinking process. The needs, requirements and/or perspectives of the client are key considerations for children in these activities.
Design problem	A design problem is an open-ended problem that identifies a challenge, a question or a need.
Design thinking	Design thinking is an action-orientated and practical process to support creative problem-solving and innovation.
Digital literacy	Digital literacy is the skills, knowledge and dispositions needed to successfully navigate the ever-evolving digital world.
Digital tools	Digital tools include devices, web browsers, software and other digital technologies.
Digital system	Digital systems are different parts of hardware and software components that work together to enable a system to function. Digital systems work by receiving, processing and outputting data.
Ecosystem	An ecosystem refers to a community of living organisms, such as plants and animals, interacting with each other and their physical environment in a specific area.
Electric circuit	An electric circuit refers to the complete path of an electric current around a series of wires and connections; if there is a break in the circuit the current will not flow.
Empathy	Empathy involves perspective-taking, understanding, being aware of, being sensitive to, and sometimes vicariously experiencing the emotions, feelings, thoughts, and experiences of another.
Energy	Energy can be defined as the ability to cause change and may be recognisable in different forms such as sound and light.

Environment	An environment refers to the surroundings, natural and man-made, where plants, animals and humans live together.
Evidence	Evidence refers to the available body of facts or information indicating whether a proposed explanation is valid or trustworthy.
Fair test	Fair tests are scientific investigations that endeavour to answer testable questions. In a fair test only one variable is changed, and all other conditions remain the same.
Food chain	A food chain is the order in which organisms (living things) depend on each other for food.
Force	A force is an interaction that changes the motion of an object if unopposed. Force is loosely understood as being a push or a pull. It can make an object speed up, slow down, stop, change shape or change direction or can hold an object in place.
Friction	Friction is a force that opposes movement.
Gravity	Gravity is a force of attraction between all bodies in the universe. The force of attraction between objects depends on their mass; the greater the mass of an object the greater the force of attraction.
Habitat	A habitat is a place where an organism lives. It provides a particular set of conditions for life and it may be large (a field) or small (a leaf).
Hands-on and minds-on learning	Hands-on and minds-on learning involves engaging in higher-level thinking and active learning.
Human system	A human system is groups of organs and tissues that work together to perform an important function of the human body.
Imagined problem	An imagined problem refers to a hypothetical or fictional problem created for the purpose of simulating an engaging Learning Experience of interest. Imagined problems can be inspired by stories, children's play, observed activities or from children's own ideas or wonderings.
Input	An input is the information or instructions provided to a digital or non-digital technology.
Insulator	An insulator is a material/substance that does not allow heat/electricity to flow through it.
Iterations	Iterations are changes that are made to a design or a process to improve its use and effectiveness.
Magnification	Magnification is the apparent enlargement of an object by an optical instrument.
Nature of STEM	Nature of STEM refers to what STEM is, how it works and how it relates to the world around us.
Observation	An observation involves using the senses to obtain information about objects and events.
Output	An output is the result produced by the information or instructions provided to a digital/non-digital technology.
Plugged activities	Plugged activities engage children in the process of computational thinking and computing with the use of digital technologies.
Precise instructions (Digital technologies)	Precise instructions refer to specific actions in an algorithm that direct the process of solving a problem or completing a task.
Process (Digital and non-digital technologies)	A process refers to digital/non-digital technology using the information or instructions provided by the input to make something happen (output).
Programming	Programming is the process of writing instructions (algorithms) in a language that a program on a digital tool can follow.
Properties of materials	Properties of materials refer to the features of materials that enable us to compare and contrast materials.

Prototype	A prototype is an early sample or a first draft of a design/creation which can be adapted.
Real-world problem	A real-world problem refers to a problem that is generated from children's real-world experiences. Real-world problems could be identified from children's local environment, their personal experiences/ interests or the news.
Refraction	Refraction is the change of direction of light when it passes from one transparent medium to another, for example, from air to glass, water or plastic.
Scientific inquiry	Scientific inquiry refers to the range of ways in which scientists investigate and study the world and propose explanations based on evidence.
Simulation (Digital)	Simulations are representations that replicate a real-life situation or system and allows the user to test ideas or practise skills on a computer or device.
STEM eyes	STEM eyes refer to looking at the world through the perspective of Science, Technology, Engineering and Mathematics (STEM).
STEM starters	STEM starters typically involve short, open-ended questions, problems, or challenges to spark children's interest and trigger STEM Learning Experiences.
Teachable moments	Teachable moments occur where a teacher identifies that children would benefit from a short pause during a lesson to focus on the acquisition of specific and/or targeted disciplinary knowledge, skills or perspectives that can deepen and enhance their overall learning experience.
Technologies (digital and non-digital)	There are both digital and non-digital technologies. Examples of digital technologies include computers, smartphones and digital clocks. Examples of non-digital technologies include pens, paperclips and mechanical clocks.
Testable question	A testable question is a question that can be investigated by experimental inquiry.
Unplugged activities	Unplugged activities engage children in the process of computational thinking and computing without the use of digital technologies.
User need	User need describes the problem, requirement or challenge that a person(s) has, that an engineer can help solve by designing, creating or improving something.
Variables	Variables are anything that can be measured, changed or kept the same during investigations e.g. when growing plants, children may change the amount of water each plant receives, while keeping everything else the same.

NCCA
An Chomhairle Náisiúnta Curaclaim agus Measúnachta
National Council for Curriculum and Assessment

Enacting the curriculum:

Guidance for teachers' preparation – An Approach to Integrated STEM Learning

Guidance for teachers' preparation: An Approach to Integrated STEM Learning

Integrated STEM offers valuable opportunities for children to bring their learning together and use it in meaningful ways. By connecting ideas from Science, Technology, Engineering and Mathematics, children can explore real-life situations and begin to look at the world through STEM eyes. In doing so, they think and work in ways that reflect how STEM is used beyond the classroom.

Integrated STEM learning often begins with a question, issue or challenge that is relevant to the children's lives. These starting points may come from children's own ideas, interests and observations about the world around them, or from imagined scenarios that spark curiosity and discussion. Beginning with children's wondering creates authentic opportunities for them to apply what they know, make connections across their learning and deepen their understanding. Integrated STEM learning also creates space for creativity and playfulness. Teachers ensure that Learning Experiences appropriately support children to apply, reinforce and consolidate their STEM knowledge and to develop or strengthen skills, aligning with the *STEM Education* specification.

There are many ways to prepare for an integrated STEM Learning Experience. One suggested approach is a five-phase process outlined in *An Approach to Integrated STEM Learning* (see p.49 in the *STEM Education* specification). This approach provides a supportive context in which children can build confidence in their thinking, collaborate with others and engage with learning in purposeful and enjoyable ways.

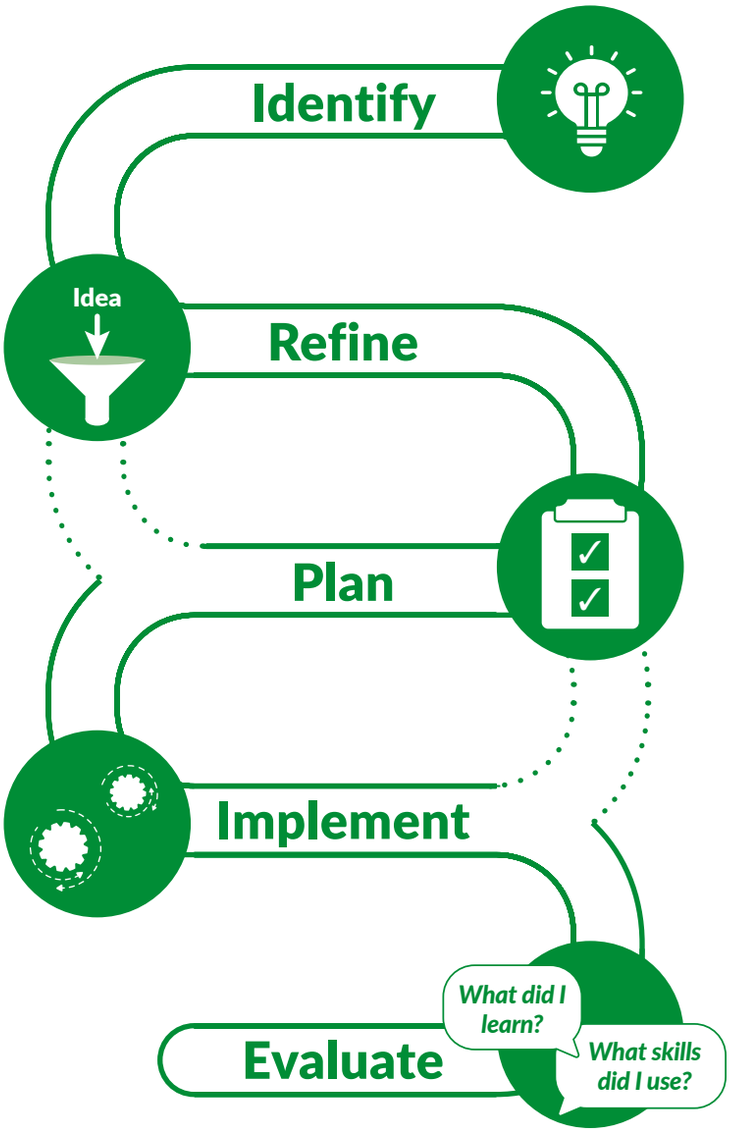


Figure 1: An Approach to Integrated STEM Learning phases

The following practical suggestions may support preparation:

- Every class should have the opportunity to engage in at least one of these Integrated STEM Learning Experiences during each school year.
- The Focus(es) of Learning and associated Learning Experiences may draw on Learning Outcomes from two or more the STEM subjects (Science, Technology, Engineering and Mathematics).
- Mathematics should be meaningfully integrated into all Learning Experiences in this approach to integrated STEM learning. Children should be supported to *mathematise* STEM challenges, that is, to frame relevant aspects of the challenge in mathematical terms and to apply relevant mathematical skills and knowledge as outlined in the *Primary Mathematics Curriculum*. This may include, for example, measuring, estimating, working with data or identifying patterns.

An Approach to Integrated STEM Learning: Time allocations

Time allocated for dedicated integrated STEM Learning Experiences in this approach, should be drawn from both the suggested time allocations for *Primary Mathematics Curriculum* and *STE Education* specification. A suggested proportion is a 3:1 ratio of Mathematics time to STE time. Where appropriate, teachers may also draw on Flexible Time to support this learning.

For example, if a teacher plans for a 5-hour Integrated Learning Experience, the time could be allocated as follows:

- At least 3 hours from Mathematics time
- At least 1 hour from STE time
- Up to 1 hour from flexible time.

An Approach to Integrated STEM Learning: Refining problems and challenges

Children should, in collaboration with the teacher, select a challenge of interest and relevance to them. Refining this challenge is an important task for both the children and teacher, ensuring that it is age-appropriate, safe and manageable within the school or classroom context. Where particular environments, materials, or devices are unavailable, the challenge should be adapted to remain practical and workable.

An Approach to Integrated STEM Learning: Supporting skills development

Table 4 on p.55 of the *STEM Education* specification outlines STEM-specific and transferable skills which can be developed through STEM Learning Experiences. This Table is a support for preparing integrated STEM Learning Experiences and can be used, for example, to help teachers to identify:

- skills to focus on during STEM Learning Experiences
- skills to teach explicitly
- skills to observe for assessment.

It is important to note that the skills included on Table 4 are not an exhaustive list, other STEM skills may be identified and developed through a range of tailored STEM Learning Experiences.

An Approach to Integrated STEM Learning: Examples

The examples in Table 1 and Table 2 illustrate how *An Approach to Integrated STEM Learning* may be used in schools. They demonstrate the potential for children to look at the world through STEM eyes and explore how they can integrate and apply their understanding of Science, Technology, Engineering and Mathematics to solve problems or address issues that are shaped by their own interests, wonderings and curiosities.

The teacher uses their knowledge of the children to refine the problem or challenge such that there are opportunities for the children to apply, reinforce and consolidate their existing knowledge and apply or develop new skills in line with the *STEM Education* specification.

When preparing for *An Approach to Integrated STEM Learning*:

- **Learning Outcomes**, or aspects of Learning Outcomes, are selected to support children to build upon and apply their prior STEM learning. It is likely that the children will already have experience in working towards these Learning Outcomes. Through this integrated approach, children use, connect and strengthen their previous learning across STEM in rich, meaningful contexts
- The **Focus(es) of Learning**, drawn from the Learning Outcomes, likely emphasises children generalising and applying their STEM learning to solve problems or challenges
- **Learning Experiences** provide opportunities for children to use and develop STEM skills (see p. 55 of the *STEM Education* specification), and to engage with the Elements of the *STE Education* specification and the *Primary Mathematics Curriculum* (see section 6b of each).

Football Challenge – Stage 4

Through appropriately playful and engaging learning experiences, children should be able to:

Science	Engineering
identify and discuss the properties of materials that need to be considered when constructing objects, structures, fashion and food. AL, CL, M	working collaboratively, consider user needs when defining and refining design problems and solutions. Use sketching and traditional or digital tools to design plans. Make and test at least one prototype and evaluate the design solution. Draw conclusions and present an analysis of the iterative design process. AL, C, DL
Mathematics	
interpret scale maps and create simple scale drawings.	

Phases of Integrated STEM learning

Identify: The children are asked to brainstorm and generate questions and wonderings about any issues in the school that they would like to try and fix themselves.

One group of children brings up the issue of the football going onto the school roof. This happens when the ball is kicked from certain positions or at a particular angle. When the ball lands on the roof, it then rolls down onto the road in front of the school, and their game of football is over until a member of staff can retrieve the ball. There is a common consensus that this is a real problem that they would all like to try and fix.

The teacher identifies this as a meaningful and relevant real-world STEM problem, integrating and applying the children's prior learning in Science, Mathematics and Engineering, with potential to develop a range of skills.

Refine: The children are encouraged to break down the problem and consider its various components, e.g.,

- there is nothing to stop the ball going onto the roof
- the shape of the roof leads to the ball regularly rolling onto the road instead of back into the yard
- the school fence is not high enough to prevent the ball from going onto the yard
- they are not allowed get the ball if it goes out of the school grounds.

The children are encouraged to critically identify aspects of the problem that they can feasibly try to solve. They decide that while they cannot change the shape of the roof, they could create a structure that channels the ball back into the school yard.

The teacher, drawing on their knowledge of the children, identifies the following opportunities for the children to use, apply and consolidate their prior knowledge and skills in STEM Education:

- Defining and refining design problems and making and testing a prototype in response to a specific design need (*Engineering*)
- Identifying and discussing the properties of materials that need to be considered when making structures (*Materials*)
- Using scale drawings to accurately represent familiar structures and to support the design of constructions (*Shape and space*).

Plan: The children decide that they want to design an appropriate structure for the caretaker to put on the roof at lunch time to prevent the ball from rolling out of the school grounds and they would also like the design to channel the ball back into the yard.

The children go out to the yard to look at the roof and fence with STEM Eyes. Then, they are put into groups to initiate their plans. They record a step-by-step approach to how they will design their solution and they list resources or materials required. They decide to sketch initial plans and soon determine that they will need to create scale drawings to support the development of accurate prototypes, using either digital tools or graph paper. The caretaker is invited into the classroom to consult on the feasibility of their plans. The caretaker informs the children that he would not have time to put the designed item up on the roof every day and asks them to consider a solution that could be fixed on the roof and to make sure the materials they select are weatherproof.

Implement:

- The children research and conduct inquiries into the properties of the materials available to them, searching for a weatherproof material that can absorb the force and flight of the ball.
- They create scale drawings of the school, using measurements taken from the school yard and a simple scale. As they are unable to reach the roof, they take photographs and use these to deduce the measurements and angles they need with as much precision as possible.
- They design prototypes of 3-D structures that will catch and channel the ball back into the school yard. They use their scale drawings to estimate the measurements required and refine these throughout the testing process.
- They go through cycles of prototyping and testing models of potential structures in the classroom.
- Drawing on the features of models that work well, the class create a final design.
- The children make the structure, and the caretaker installs it on the roof.
- The children test the structure for functionality and make some refinements to strengthen the structure.

Evaluate: The children collate and present an account of their approach to this integrated STEM Learning Experience.

The children consider:

- key learning from the experience
- the STEM knowledge and skills they used to solve this problem
- the functionality of their design
- aspects of the process that worked well and aspects of the process that were challenging
- what they would modify or do differently if they were to approach this problem again
- what questions, problems or challenges remain and can be investigated further.

Table 1: An Approach to Integrated STEM Learning – A senior class example

Boat Builders – Stage 1

This example shows the potential for integrating STEM across Science, Technology, Engineering and Mathematics. While there is a wide range of Learning Outcomes considered in this example, the teacher uses their professional agency to identify the Learning Outcomes, and number of Learning Outcomes, that are most appropriate to support the children to apply, reinforce and consolidate their STEM learning.

Through appropriately playful and engaging learning experiences, children should be able to:

Science

explore a range of common materials found indoors and outdoors. Identify the main properties of these materials, what they are made of and the ways they can be used in different contexts. AL, CL

explore and investigate the effect that different forces have on objects including pushing, pulling, floating and sinking. AL, CL

Engineering

explore real and imagined design problems that are relevant to their lives. Communicate and share ideas about how these design problems might be solved. Plan and make a simple prototype to solve a design problem and reflect on the process they undertook. AL, C, CL

Nature of STEM

explore and experience how people working in Science, Technology, Engineering and Mathematics (STEM) carry out investigations and help to solve problems, big and small, that impact our world. AL, DL, M

Technology

build on their awareness of a range of digital and non-digital technologies that they encounter in their everyday lives. Explore and discuss how these technologies help us and those around us to live and work in the world. AL, DL, W

Mathematics

demonstrate an awareness that attributes such as length, weight, capacity and area can be measured and compared.

explore and recognise properties of 3-D and 2-D shapes.

Phases of Integrated STEM learning

Identify: The children in senior infants have been exploring STEM storybooks, learning about investigating, problem solving and design. The teacher has been noticing the children's interest in the storybooks, observing how they talk about and play games relating to the themes and issues explored. She decided to draw on these interests as stimuli for real or imagined integrated STEM Learning Experiences. One of the children shared a story about how they tried to make a boat to float on the local pond, but that it didn't float and was ruined in seconds. Another child asked why they didn't test it in the sink first. The rest of the children were eager to add ideas and potential solutions to the conversation. The teacher identified that building a boat (a piece of technology) would provide a meaningfully integrated STEM Learning Experience. The teacher asked the children if they would like to use STEM to become boat builders and there was a unanimous cheer.

Refine: The teacher, in reflecting on the children's learning journey during the year, determined that the children could draw on their prior STEM learning in the following areas to address this challenge:

- Investigating the properties of materials (*Materials*)
- Exploring and investigating what materials float or sink (*Energy and forces/Materials*)
- Using non-standard units to measure and make structures for a specific purpose (*Measures*)
- Making and refining structures using 3-D shapes (*Shape and space*)
- Using STEM to explore and solve problems (*Nature of STEM*)
- Making a simple prototype (*Engineering*)
- Exploring how technologies (i.e., the boat) can solve problems (*Technology*).

The children helped the teacher to further refine the challenge by deciding on the criteria/constraints for the boats:

- It must float for at least one minute.
- It must be designed so that it will stay upright and stable under the weight of its passengers (the class mascot and another toy of their choice).
- It should be an appropriate size so that it can hold its passengers and fit in the classroom sink (for testing).
- It must be able to be pushed from one side of the paddling pool to the other
- It can have a theme.

Plan: As part of a whole-class discussion, the teacher helps the children to decompose the challenge for their planning. Together, they discuss the need to investigate the available materials to discover which materials can float. They will further test those materials to see which can carry the weight of the toy passengers. They also discuss the importance of building the boat so that it will stay upright and stable as it sails across the water, keeping the passengers safe.

In small groups, they are encouraged to make basic step by step plans, including oral plans and basic drawings of their boats. The children choose what materials they would like to investigate and what resources will be needed for their boats. They begin to consider what the boat might look like and what kind of designs might or might not work, e.g., a flat base versus a curved base. They decide which toys might be practical to use as passengers, considering their size and weight.

They design the shape and size of their boats and consider its functionality, i.e., how the passengers will stay in the boat and not get wet.

Implement:

- investigate the available materials to find out what materials are waterproof and float
- explore how the properties and attributes of the shapes they use in their design affect its ability to stay afloat under the weight of the passengers (e.g., testing flat and curved bases, narrow and wide bases, etc.)
- estimate and measure the size of boat needed using non-standard units where appropriate (e.g., measuring the sink using blocks, handspans, etc.) so that it carries the passengers and fits in the sink
- make their designs
- test to see if their piece of technology (the boat) functions as intended and make modifications where necessary.

Evaluate: The children test (sail) their boats in a paddling pool (or similar). They present to the class, teacher, principal and/or STEM guest and tell (in sequence) how they made their boats.

The children consider:

- what they learned about floating, sinking and materials
- what they learned about how the properties and attributes of 3-D shapes influenced their designs
- what they noticed about how their use of measuring helped them to build a suitable boat
- what they found helpful and what was challenging throughout the Learning Experience
- if they had to start again, what they would change about their materials, design and build.

Table 2: An Approach to Integrated STEM Learning – A junior class example

While *An Approach to Integrated STEM* provides a dedicated space for children to connect, apply, reinforce and consolidate their prior learning, it is possible that new ideas and understandings in STEM will emerge throughout Learning Experiences. Teachers use their professional agency in choosing how to address this, e.g., they may decide to scaffold or extend this learning through a discrete Science, Technology, Engineering or Mathematics lesson.

Through the course of the problem or challenge, teachers may also use 'teachable moments' to address misconceptions or respond to gaps in children's understanding.

Considerations for Whole-School Curriculum Planning

Schools can:

- develop a shared understanding how *An Approach to Integrated STEM Learning* can bridge learning across Science, Technology, Engineering Education and Mathematics
- support teachers to provide opportunities for children to engage with at least one Integrated STEM Learning Experience per year.

NCCA
An Chomhairle Náisiúnta Curaclaim agus Measúnachta
National Council for Curriculum and Assessment

Enacting the curriculum:

Guidance for teachers' preparation in Mathematics

Introduction

The successful enactment of the *Primary Mathematics Curriculum* (PMC) relies on effective preparation for learning, teaching and assessment by teachers and schools. This is about bringing to life what is set down in the PMC and embedding it in children's Learning Experiences that reflect the vision of the curriculum. This involves purposeful engagement with the PMC and its supports, as well as the development of whole-school curriculum plans and whole-school agreed approaches to ensure high quality Learning Experiences are provided for every child.

This guidance offers practical, accessible support for designing playful, engaging Learning Experiences in line with the *Primary Curriculum Framework* and the PMC. Teachers' preparation for effective learning, teaching and assessment enables them to make purposeful and informed decisions when working with the PMC.

Teacher agency is central to this process. Teachers exercise agency by making professional decisions based on children's interests, curiosities and prior learning, and on the curriculum and whole-school approaches. The opportunities for agency available to teachers support preparation for Learning Experiences that are responsive to the unique context of their school. Also important is the recognition and nurturing of children's agency as their capacity to act on, participate in, and make choices about their learning within Mathematics. Throughout this guidance there are prompts, suggestions and reflections designed to foreground both child and teacher agency as central to effective preparation.

This guidance provides the basis for schools' and teachers' preparation with the PMC. This guidance complements the following materials:

- *Whole-School Curriculum Planning: Guidance for all Primary and Special Schools*
- *Preparation for Learning, Teaching and Assessment: Updated Guidance for all Primary and Special Schools*
- Updated Assessment Guidance for Primary and Special Schools
- Pedagogy and inclusion support materials.

To access these materials visit the Primary Curriculum Toolkit on **www.curriculumonline.ie**.

The *Science, Technology, Engineering and Mathematics (STEM) Education* specification is presented in three parts:

- The *Science, Technology and Engineering (STE) Education* specification
- An Approach to Integrated STEM Learning
- The *Primary Mathematics Curriculum*.

Similar to the *STEM Education* specification, guidance for teachers' preparation in this document is presented in the same three parts:

- Enacting the curriculum: Guidance for teachers' preparation in Science, Technology and Engineering (STE) Education
- Guidance for teachers' preparation: An Approach to Integrated STEM Learning
- Enacting the curriculum: Guidance for teachers' preparation in Mathematics.

 Throughout this document, reference is made to the Primary Mathematics Toolkit. The symbol is used to highlight various resources available to teachers in the toolkit to support them in their preparation for Mathematics learning and teaching.

Linking teachers' preparation to Whole-School Curriculum Planning

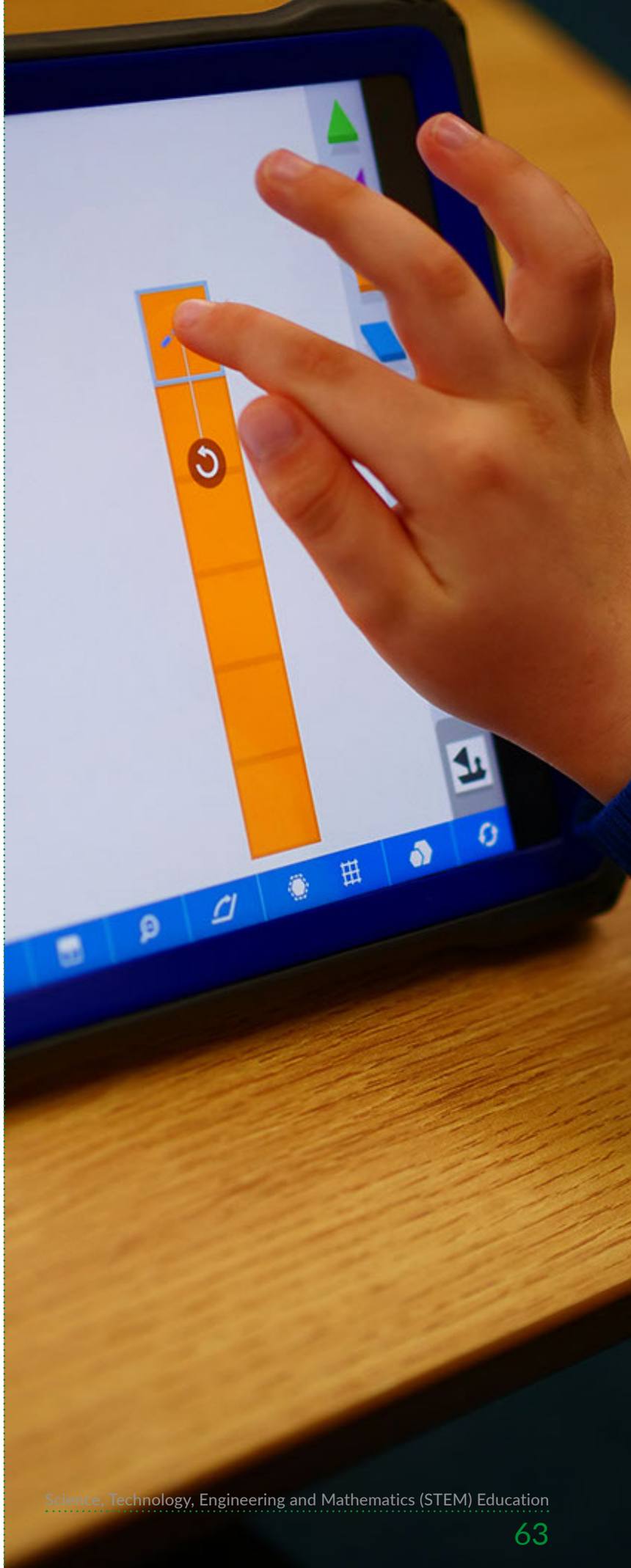
Individual teachers' preparation does not take place in isolation. It is shaped by the PMC, collaborative Whole-School Curriculum Planning, School Self-Evaluation and Action Planning. These all work together to guide effective learning, teaching and assessment.

Whole-School Curriculum Planning is especially important. It helps schools to agree on a shared approach to using the PMC. This includes the sequencing of children's learning across Stages 1 – 4, and how Learning Outcomes, Elements, Pedagogical Approaches and Assessment Guidance are used.

Following the process in *Whole-School Curriculum Planning: Guidance for all Primary and Special Schools* will lead to the successful development of a Whole-School Curriculum Plan for Mathematics. The plan should set out the agreed approaches which are necessary for teachers in a particular school context working with chapters 5 and 6.

The Whole-School Curriculum Plan acts as a guide for teachers' individual preparation. Teachers should align their preparation with both the specification and the school's agreed plan. This helps ensure consistency between Whole-School Curriculum Planning and classroom practice.

Within this guidance, prompts are included to help guide schools when considering Whole- School Curriculum Planning. This is a non-exhaustive list and schools may adapt or add to them based on their own context.



The *Primary Mathematics Curriculum*

The over-arching aim of the *Primary Mathematics Curriculum* is the development of mathematical proficiency. This encompasses:

- Conceptual understanding
- Procedural fluency
- Adaptive reasoning
- Strategic competence
- Productive disposition.

Each aspect is important, interwoven and interdependent. They are developed over time as children engage in rich, playful and engaging mathematical Learning Experiences. When preparing, teachers consider what children will learn and, importantly, how they will learn. Through opportunities to engage with the Strands, Strand Units and Elements of the PMC, and through teachers' skilful use of key pedagogical practices, children become increasingly proficient in Mathematics.

 The *Primary Mathematics Toolkit* includes an overview of mathematical proficiency, which provides further detail regarding each of the five aspects.

What children learn in Mathematics

Learning Outcomes in the PMC are organised into five strands (*Algebra*, *Data and chance*, *Measures*, *Number*, *Shape and space*). These strands encompass the main categories of mathematical learning. Each strand is further broken down into strand units (Figure 1), which outline more specific areas of learning to be developed.

The strands and strand units provide a practical structure for supporting preparation for learning, teaching and assessment. Each strand is important, and teachers should include all Mathematics strands and relevant strand units in their preparation throughout the year.

In practice, learning, teaching and assessment often move fluidly across strands, and natural overlaps may occur. Teachers may choose to begin with any of the strands in their preparation.

Algebra	Data and chance	Measures	Number	Shape and space
Patterns, rules and relationships	Data	Measuring	Uses of number	Spatial awareness and location
Expressions and equations	Chance	Time	Numeration and counting	Shape
		Money	Place value and base ten	Transformation
			Sets and operations	
			Fractions	

Figure 1: Strands and strand units of the *Primary Mathematics Curriculum*

Making connections across strands and strand units

When preparing, it is possible and useful to consider relationships across strands, highlighting the connected and interrelated nature of mathematical content. This supports children to build upon their prior learning and to deepen their understanding. For example, when analysing a data set relating to traffic in their local area, children may consider patterns in the data and use these to identify or predict busier or quieter times of the day for a school outing. Further examples of connections across strands are outlined Chapter 4 of the specification. Where possible, teachers are encouraged to anticipate these connections and incorporate them into their preparation to support more coherent and meaningful Learning Experiences.

The Directory of strand unit support materials (Figure 2) found in the *Primary Mathematics Toolkit* contains a suite of seven supports for each of the fifteen strand units. The Directory is designed to respond to particular questions or wonderings teacher might have as they work with the strands and strand units (see Table 1). Teachers draw on this guidance as required, using their professional agency to adapt for their unique context.

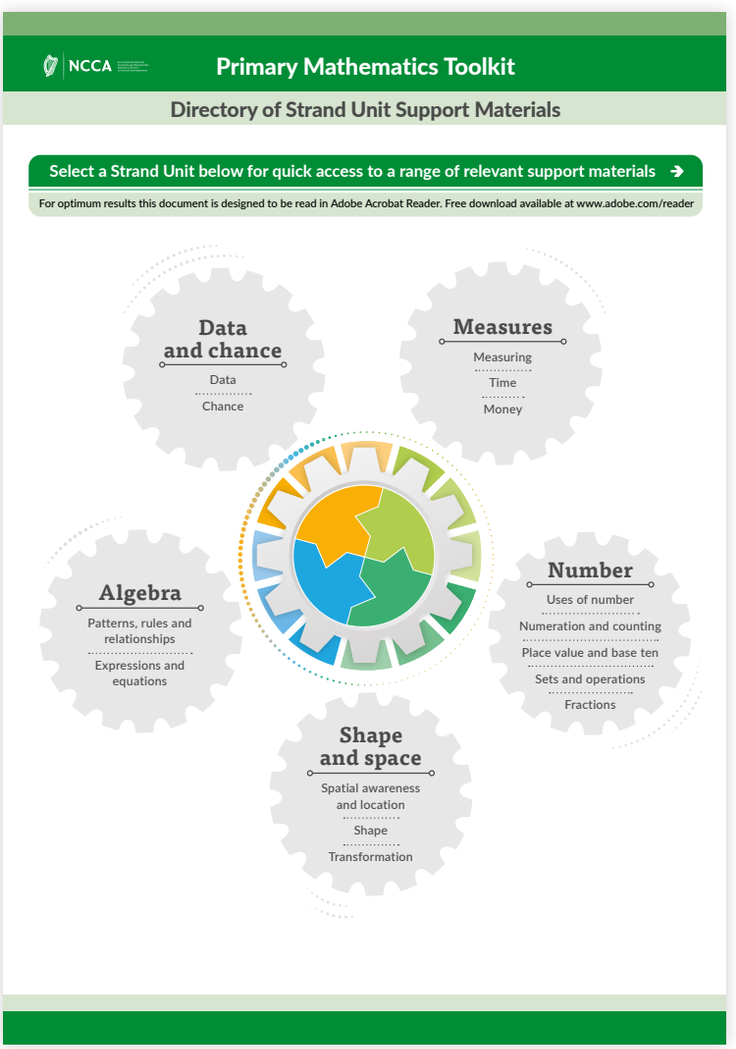


Figure 2: The Directory of strand unit support materials

Teacher question	Toolkit support material
What concepts or ideas would be important for children to understand?	Mathematical concepts
What might a child's learning journey or progression look like?	Progression continua
What might playful and engaging experiences look like?	Suggestions for children's learning
What pedagogical practices might be effective to support children's learning in this area?	Suggestions for teaching
What key language is important?	Suggestions for key language
How can the learning environment be organised and enhanced?	Suggestions for the learning environment
How can children's learning at home be supported?	Suggestions for learning at home

Table 1: Using the Directory of strand unit support materials

How children learn in Mathematics

How children learn is as important as what they learn. Figure 3 represents the relationship between the strands (the 'what' of Mathematics learning) and the Elements (the 'how' of Mathematics learning).

Elements describe the mathematical processes that support meaningful Mathematics learning. These are:

- understanding and connecting
- communicating
- reasoning
- applying and problem-solving.

The Elements are the central cog which, when engaged, activate the learning in and across strands. In preparing for Mathematics learning, consideration should be given to both what and how children will learn.

Preparation for learning, teaching and assessment ensures that children have the opportunity to engage in these Elements regularly. In playful and engaging mathematical Learning Experiences, the Elements are visible in action – the children understand and connect, communicate, reason and apply and problem-solve. It is encouraged that children will engage with more than one Element at a time. For example, a child will have opportunities to *communicate* their ideas and mathematical thinking through the process of *applying and problem-solving* (e.g., sharing and comparing approaches). A child will likely engage in *reasoning* when *connecting* new and prior learning (e.g., drawing on prior learning in *Place value and base ten* when converting in *Measures*).

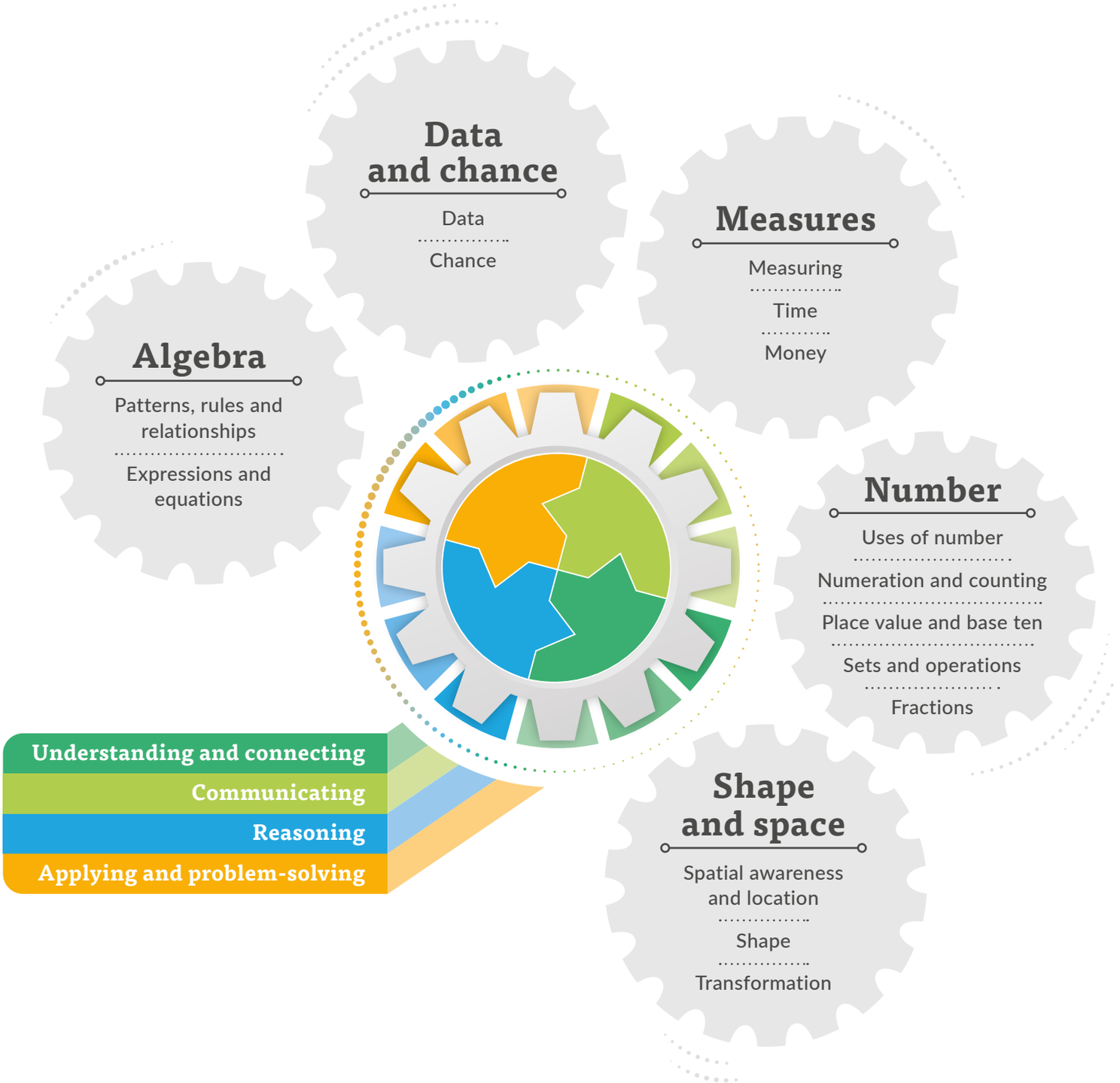


Figure 3: Strands and Elements of the *Primary Mathematics Curriculum*

Supporting children's mathematical learning

To support children's learning, teachers draw on a range of pedagogical practices. Section 6b of the PMC outlines five such practices that are particularly important in the provision of rich and meaningful learning experiences in Mathematics.

Importantly, teachers are best placed to make decisions regarding their use of pedagogical practices. These decisions are based on how well they respond to and support children's learning. For example, rather than preparing for Learning Experiences that centre around a particular pedagogical practice (e.g., an 'Emphasising mathematical modeling' lesson), teachers seek opportunities to draw flexibly on their repertoire of pedagogical practices and use these, with intention, to support learning and progression. For example, a teacher may notice that children would benefit from opportunities to make sense of and describe their mathematical learning with greater confidence or accuracy. In response, they seek opportunities to promote maths talk and to encourage children to represent, describe and refine their thinking by emphasising mathematical modeling.

The pedagogical practices interconnect and complement each other. Therefore, it is likely that teachers will draw on more than one pedagogical practice throughout the course of a Learning Experience. For example, through the use of cognitively challenging tasks, children are encouraged to grapple with ideas and approach problems and solutions freely and flexibly. In turn, this encourages playfulness in Mathematics, as the teacher is providing opportunities for children to explore and be creative.

 The Primary Mathematics Toolkit provides a range of support materials to inform and support teachers' use of key pedagogical practices.

Considerations for Whole-School Curriculum Planning

Schools can:

- ensure breadth, balance and inclusive participation for all children across all stages
- use the Elements as a guide to the 'how' of children's learning
- consider and support the responsive use of pedagogical practices in Mathematics.

Key Competencies, Learning Outcomes, Focus(es) of Learning and Learning Experiences

Key Competencies

attention. As children work towards the Learning Outcomes in the PMC and engage in rich learning experiences, they simultaneously build and develop these key competencies. In preparing for Mathematics, it is essential teachers provide opportunities for children to develop as active learners, communicators and users of language, creative thinkers, mathematical learners, digital learners and active citizens while developing their understanding of being well. This requires intentionality, and therefore teachers should be mindful of how the key competencies, including their attributes, are being realised through the curriculum.

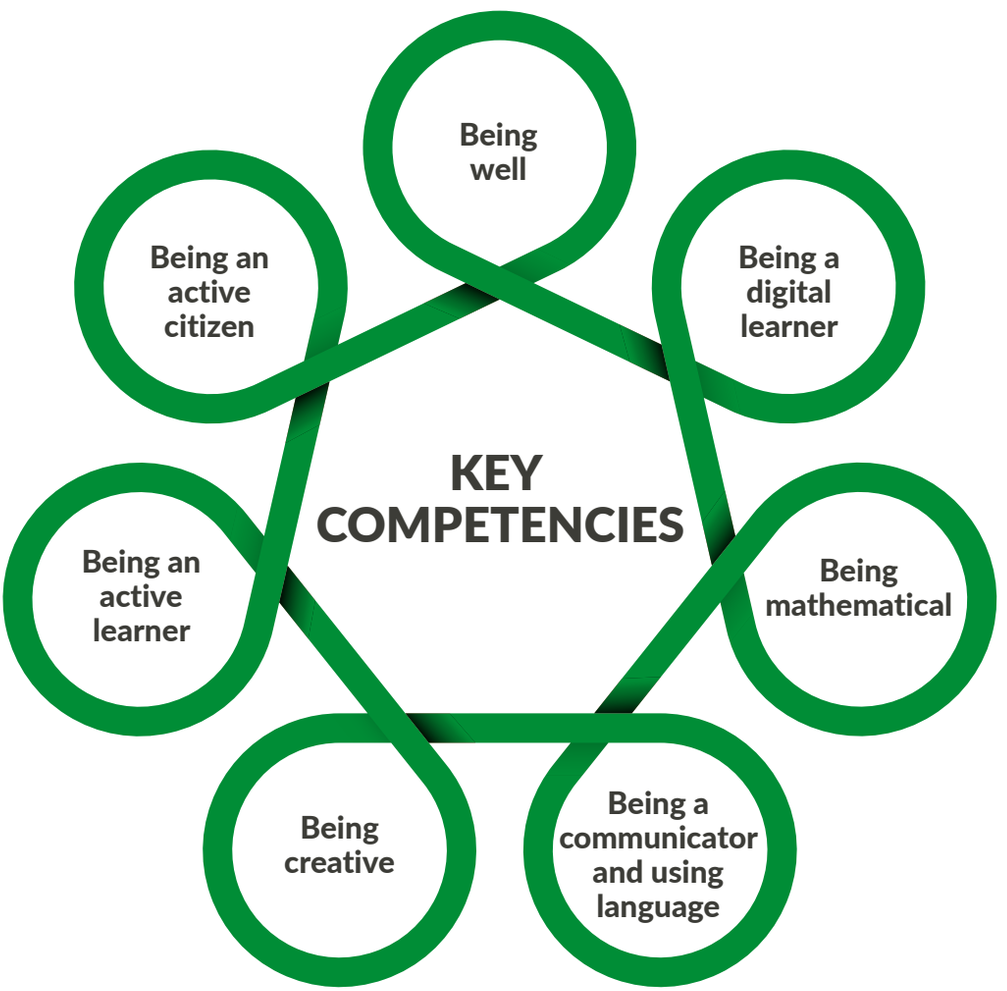


Figure 4: Key competencies

As outlined below, the Learning Outcomes anchor preparation; the Focus(es) of Learning clarifies what children will learn next; and the Learning Experiences provide appropriately playful and engaging opportunities for all children.

Learning Outcomes

As a teacher prepares for learning, teaching and assessment, all decisions should be informed by:

- Knowledge of children and their prior learning, strengths, abilities, interests and needs
- Knowledge of the curriculum, including its vision, principles, key competencies and Learning Outcomes in the specifications
- Knowledge of pedagogy and assessment, including approaches described within the specifications.

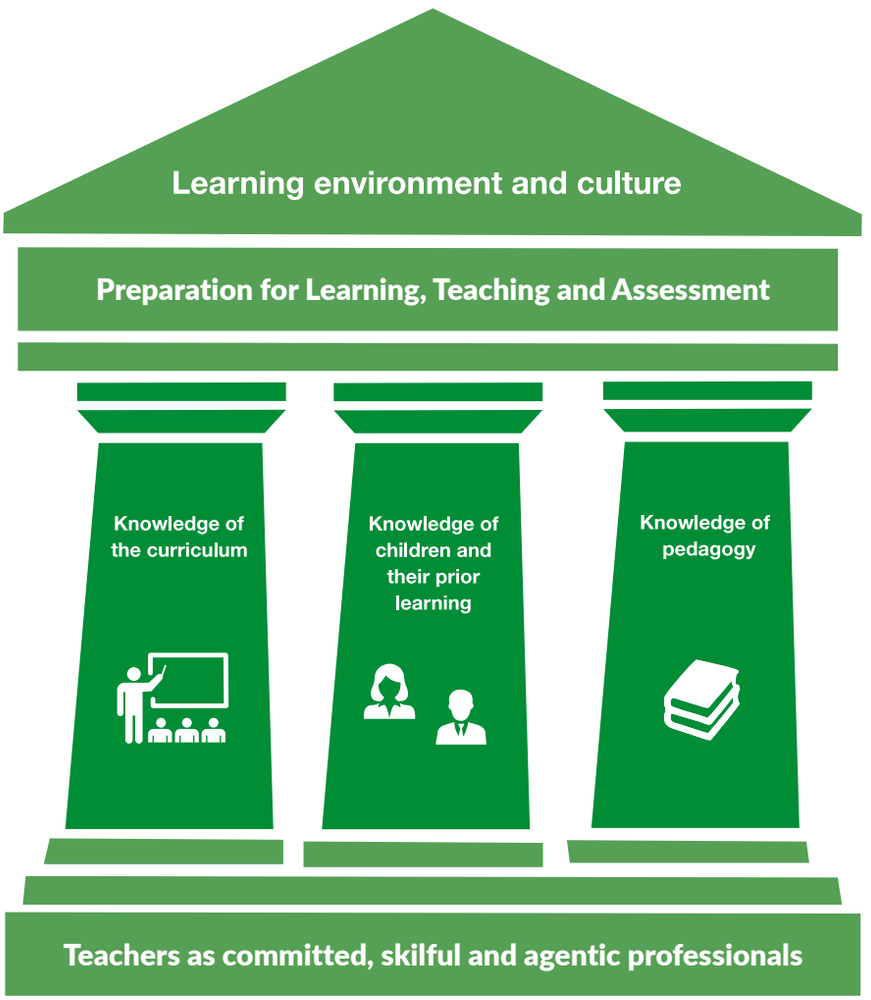


Figure 5: Teacher preparation

The Primary Mathematics Toolkit provides key considerations for teachers to support and inform preparation for learning, teaching and assessing Mathematics in the classroom. These prompt teachers to consider their knowledge of the children, curriculum and pedagogy and assessment.

The processes of learning, teaching and assessment are complex, fluid and dynamic; while being complementary to each other. In recognition of this reality 'Entry Points' are where a teacher begins their preparation in working with the Learning Outcomes. There are many possible entry points when preparing for learning and teaching including Learner entry points, Curriculum entry points and Contextual entry points. The entry points are examples, not a checklist.

Regardless of the entry point, selected Learning Outcomes as well as knowledge of the curriculum anchor preparation and ensure alignment with the curriculum.

Learner entry points

- Children's questions, wonderings, observations and lines of inquiry
- A theme or topic linked to children's interests and prior learning
- Identified needs, areas for development or strengths in learning suggested by assessment information

Curriculum entry points

- The Learning Outcomes of the specifications
- The key competencies of the curriculum

Contextual entry points

- A local, national or international event or topical issue
- An engaging Learning Experience observed or shared by a fellow teacher or through professional learning
- Spontaneous teaching opportunities (e.g., gathering and analysing data at a school or local sports event, working with measures when preparing for a school bake sale)

Learning Outcomes support preparation that enables every child to learn and develop. In the main, they describe the expected learning and development at the end of each stage (a two-year period). They are designed to be broad and flexible to support progression in learning for every child. Ongoing, high quality assessment plays a central role in identifying each child's abilities, strengths, needs and next steps in learning, ensuring that decisions about the most appropriate Learning Outcomes are responsive, evidence informed and focused on supporting meaningful progression. It is expected that children work towards all of the Learning Outcomes for their stage. However, for some children, it may be appropriate, in particular curriculum areas and subjects, to work towards Learning Outcomes or aspects of Learning Outcomes from a different stage. These decisions should be based on knowledge of the children informed by assessment information and reviewed regularly. Longer term measures, where a child continues to work towards Learning Outcomes from a different stage, for an extended period, should be taken in consultation with the special education teacher (if applicable). This should be supported by a strong evidence base, be reflected in the child's *Student Support Plan* (SSP) in consultation with parents and reviewed regularly.

To support coherence and progression in learning and to avoid unnecessary repetition or gaps in learning opportunities, schools should consider the sequencing of learning across each stage through whole-school planning and ongoing teacher collaboration. Children will progress at different rates. Progression includes periods of new learning, practice and consolidation and it is important that, across the two-year stage, Learning Outcomes are intentionally prepared for, revisited as appropriate, and used to support children's progress towards expected learning. Across all contexts, the aim is to ensure that every child experiences meaningful progression in their learning and is supported to work towards the Learning Outcomes of the curriculum.

The PMC facilitates children to revisit and deepen their understanding of mathematical knowledge and skills as they progress through stages 1 to 4.

Most strand units span all four stages, enabling children to build on prior learning, developing greater confidence and competence over time. There are some exceptions to this, for example, children begin working towards Learning Outcomes for the strand unit *Chance* in Stage 3. This allows appropriate time and space for children to establish a level of understanding of concepts within *Numeration and counting* and *Patterns, rules and relationships* in Stages 1 and 2 which are foundational to learning in *Chance*.

In parallel with assessment information, consideration of the use of Additional Support Pathways (ASPs) may assist a teacher in identifying appropriate and meaningful entry points to support children's learning and in creating inclusive Learning Experiences for every child. ASPs are a tool designed to support more individualised learning for children with SEN. They outline different ways children might engage with or demonstrate progression towards Learning Outcomes.


Additional Support Pathways (ASPs) are contained in the Primary Mathematics Toolkit, along with other supports to promote inclusion.


The Primary Mathematics Toolkit contains *Examples of children's learning* videos, which provide insights into how teachers support children to work towards Learning Outcomes. These examples feature a range of contexts, demonstrating a variety of Learning Experiences that are responsive to the abilities, interests and needs of children.

Considerations for Whole-School Curriculum Planning

Schools can:

- agree on a whole-school approach to assessment of Mathematics in a way that supports progression, promotes inclusion and balances intuitive assessment, planned interactions and assessment events
- support teachers in identifying and using the Additional Support Pathways to create inclusive Learning Experiences, and how children with SEN may be supported to access, engage with and participate meaningfully in Mathematics.

Focus(es) of Learning

In working with the Learning Outcomes in the PMC, a teacher should identify a clear Focus(es) of Learning which includes the knowledge, skills, concepts, dispositions, attitudes and/or values that children will learn or develop next. Drawing on their knowledge of the children and their prior learning, together with their knowledge of the curriculum and knowledge of pedagogy and assessment, teachers identify the most appropriate focus(es).

There may be more than one Focus of Learning within a Learning Experience. The Focus(es) of Learning may include new learning, consolidation of prior learning, or both. In identifying the Focus(es) of Learning, a single Learning Outcome or aspects of more than one Learning Outcome may be selected from within and across specifications, facilitating integration where meaningful and appropriate. In a teacher's short-term preparation, they may record the Focus(es) of Learning in their own words, ensuring it is drawn from the relevant Learning Outcome(s). Assessment should provide opportunities for children to reflect meaningfully and demonstrate their learning in ways that are aligned with the Focus(es) of Learning.

Teachers are best placed, given their knowledge of the children in their bespoke context, to identify a Focus(es) of Learning that supports children to work towards Learning Outcomes. When identifying a Focus(es) of Learning teachers consider:

- The children and their prior learning (what they know, understand or can do now) as identified through assessment information
- Next steps in progression (for example, as exemplified in Toolkit progression supports).

Learning Experiences

Once a teacher has identified the Focus(es) of Learning, a range of appropriately playful and engaging Learning Experiences should bring the focus(es) to life. These experiences encompass what the children will do, will engage in, will experience, will create, etc., as they work towards the Focus(es) of Learning. Through their knowledge of the children, the curriculum and pedagogy, teachers prepare for the Learning Experiences.

When preparing for the Learning Experiences, it is important that they:

- Reflect the children's prior learning, abilities, interests and needs
- Support inclusion and meaningful learning
- Are enhanced by pedagogical approaches and the Elements of the PMC
- Provide meaningful and engaging opportunities for all children to actively respond to, demonstrate, contribute to, reflect on, record and apply their learning.

While Learning Outcomes, Focus(es) of Learning and Learning Experiences each play a distinct role in teachers' preparation, they are interconnected so that the children's learning is purposeful.

The following example illustrates how a teacher may prepare for a Focus(es) of Learning and Learning Experience in Mathematics.

This sample content is illustrative only, to demonstrate connections between the Learning Outcomes, Focus(es) of Learning and Learning Experiences.

It is not intended as an example of a teacher's recorded preparation.

Stage 2 – Mathematics – Shape and space (Spatial awareness and location)

The children are using their spatial knowledge for the purpose of orientation and navigation. In previous Learning Experiences, the teacher identified that they understood and used simple spatial language in a range of navigation games, tasks and activities to give and follow directions. The teacher now wants the children to build upon and extend this learning by creating and using simple maps of familiar environments for navigation purposes, using increasingly precise language.

Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to*	**Sample Focus(es) of Learning**	**Sample Learning Experiences**
use spatial knowledge for the purposes of orientation and navigation.	Connecting and applying movement in familiar environments to simple maps and using these for navigation purposes. Developing and using simple maps of familiar environments to represent locations and routes for orientation and navigation. Extending spatial vocabulary by using increasingly precise language to communicate location and directions, scaffolded by gesture, visual cues, etc. where appropriate.	The teacher shares a 'treasure map' of the classroom and school environment with the children. In groups, they follow the map, recognising and marking off key locations as they reach them. They describe and compare their routes using appropriate mathematical language (e.g., *we passed the staff room and turned right; when we got to the principal's office we turned around to come back*). The children develop models demonstrating their understanding of navigation within the classroom environment, e.g., using building blocks, drawing, using digital technologies, including important objects and features. The teacher challenges the children to test and refine their models where necessary, e.g., *Can you describe or demonstrate how I would get from the library to the door? Are you sure there are enough desks for everyone? If not, what can you adjust to fix this?* The children apply their knowledge of spatial language through adapted versions of games such as 'I Spy' or '20 questions', e.g., *I spy... something that is to the left of the teacher's desk*. Where necessary, the teacher emphasises and consolidates mathematical language by re-casting children's explanations using increasingly sophisticated and precise phrases and vocabulary. The children, drawing on their use of the teacher-designed map and their classroom models, create their own simple maps of the classroom. They consider the relative location and size of objects (e.g., tables, door, etc.). They use these maps to give verbal or written directions to their classmates to find a 'hidden treasure'. The teacher supports the children to reflect on and discuss the simple maps they used and designed, and how this supported navigation in familiar environments.

Table 2: Identifying a Focus(es) of Learning and Learning Experiences

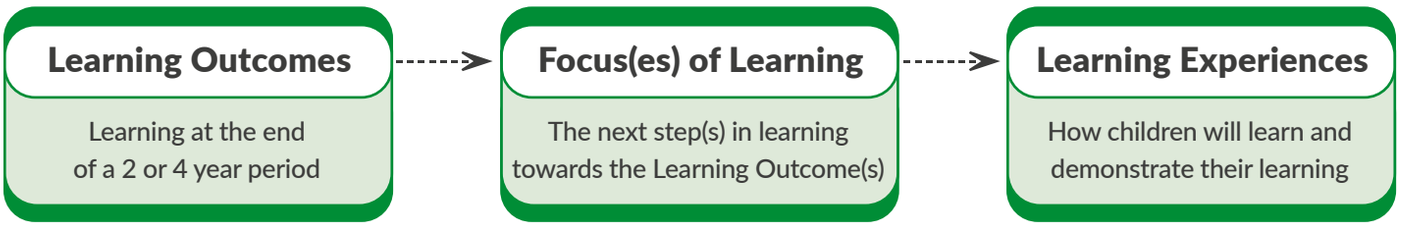


Figure 6: Learning Outcomes, Focus(es) of Learning and Learning Experiences

Considerations for Whole-School Curriculum Planning

Schools can:

- establish agreed approaches in Mathematics while supporting teachers to exercise professional judgement in responding to children's needs, interests and context
- develop a shared understanding of the use of the Additional Support Pathways to create inclusive Learning Experiences in Mathematics
- use assessment information to support the continuity of the children's learning as they progress through the school.

Organising time

The *Primary Curriculum Framework* provides the suggested time allocations to assist teachers and schools in their work with the curriculum. They are intended to be used flexibly as teachers prepare rich Learning Experiences and respond to the learning needs of children over the course of a month (based on a period of four weeks). They comprise two categories: Minimum Curriculum Time and Flexible Time. The minimum suggested weekly time allocation for Mathematics is outlined in Table 3.

While teachers have the professional agency to make decisions regarding the pace and sequencing of children's learning, in response to their bespoke context, it is likely that certain strands will be more heavily weighted in terms of time allocation. For example, the *Number* strand contains more strand units and Learning Outcomes than other strands, which will likely be reflected in the time allocated to it. This reflects the centrality of number across all mathematical content domains.

However, when preparing, it is important that all Learning Outcomes across all strands and relevant strand units receive appropriate emphasis and that Learning Experiences are underpinned by the knowledge and skills relevant to the Learning Outcomes (e.g., when working towards Learning Outcomes in the strand unit *Measuring*, while children may draw on and use their knowledge of mathematical operations (from the *Number* strand), all Learning Experiences should serve to strengthen and deepen their understanding of measures).

Stage	Suggested minimum time allocations
Stage 1	3 hours per week
Stage 2	4 hours per week
Stage 3	4 hours per week
Stage 4	4 hours per week

Table 3: Suggested minimum time allocations

There are natural connections across the five curriculum areas. These connections can be used to meaningfully integrate Learning Outcomes, resulting in time being used more efficiently, while also supporting learning, teaching and assessment in more than one curriculum area. Integration across the curriculum areas offers flexible approaches to working with time allocations. For example, when integrating Mathematics and PE instructional time may be drawn from both Mathematics and Wellbeing.

Please see guidance on the use of time for *An Approach to Integrated STEM Learning* on p. 55 of this document.


WHITEBOARD
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Integration

Integrated learning, both within and across curriculum areas and subjects, is an important part of the curriculum. It helps children see connections between ideas, deepen their understanding and apply knowledge, skills, concepts, dispositions, attitudes and values in real-world contexts. There are multiple approaches to effective preparation for integration. Below are some suggestions to help guide teachers' preparation and make integration meaningful and engaging for children's learning.

No matter where a teacher starts, they should always ask – *Will this be authentic and purposeful for the children in my class and does it offer the potential for meaningful learning?*

As a teacher prepares for integrated Learning Experiences, consideration may be given to:

- **Agency:** How have the children's interests, strengths, questions and choices as well as the teacher's professional judgement shaped the focus(es) and resources used?
- **Relevance:** Does an integrated approach reflect the children's abilities, interests and needs in the curriculum areas or subjects being integrated?
- **Learning Outcomes:** Which specific Learning Outcomes will be addressed across the curriculum areas and subjects being integrated?
- **Focuses(es) of Learning and Learning Experiences:** What is the Focus(es) of Learning and how will playful and engaging Learning Experiences support this Focus(es) of Learning?
- **Duration:** Is this a unit of integrated learning over several weeks, or a shorter integrated Learning Experience?
- **Time and balance:** How is time allocated across subjects and will one curriculum area or subject lead or be emphasised more?
- **Assessment:** How will the teacher know what children have learned or experienced and also identify the next steps in learning in the respective curriculum areas/subjects?

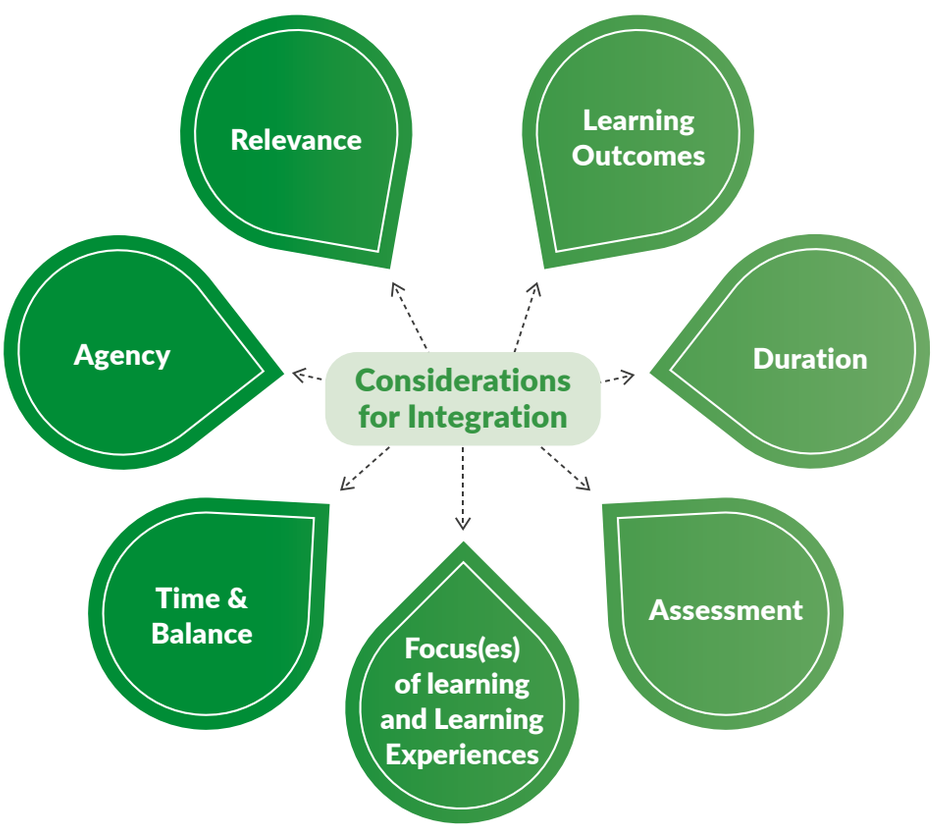


Figure 7: Considerations for Integration

When preparing for successful integration:

- Start with meaningful links – avoid forcing connections or the 'tokenistic' inclusion of curriculum areas or subjects
- Keep the integrity of each curriculum area or subject by ensuring that each one is clearly addressed through the Focus(es) of Learning
- Embrace spontaneous opportunities when they arise.

Teachers should prepare for Mathematics Learning Experiences that involve integration within the curriculum area itself (STEM Education). Table 4 presents a non-exhaustive set of examples of integration within STEM. It is not intended as an example of a teacher's recorded preparation. The samples used have been chosen by way of illustration only.

Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to*	**Sample Focus(es) of Learning**	**Sample Learning Experiences**
Stage 3 **Mathematics** **Strand:** Algebra **Strand unit:** Patterns, rules and relationships represent the relationships between quantities. **STE Education** **Strand:** Engineering use empathy to consider user-needs, risks and limitations when identifying and researching design problems. Systematically plan, make, test and evaluate a design prototype to solve at least one of these problems. Make iterations and improvements based on reflections and peer feedback. AL, C, CL	Exploring and using algebraic relationships to plan, prototype, test and iterate a design that responds to a user-need.	The teacher develops a task that draws on the children's interest in the new local park. They are asked to propose designs for ramps for the skate park. The series of ramps must cater to beginner and advanced skaters and be safe for users. To inform their design, the children investigate the relationship between the height of ramps and the distance travelled by the skateboard when released. The teacher promotes meaningful maths talk, encouraging the children to explore and discuss key questions such as: • What patterns exist between the height of the ramp and the distance the skateboard travels? • How can we record and represent this (e.g., graphs, tables, diagrams)? • How can we use this information to make safe and appropriate ramp designs? The children apply their findings to prototype, test and make iterations as needed to create an appropriate ramp.

Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to*	Sample Focus(es) of Learning	Sample Learning Experiences
Stage 2 **Mathematics** **Strand:** Number **Strand unit:** Place value and base ten		
understand that digits have different values depending on their place or position in a number. **STE Education** **Strand:** Technology explore and use a range of common digital and non-digital technologies. Consider how these technologies work and what purposes they serve in people's lives. AL, DL, W	Exploring various representations of place value in numbers and using these in operations. Using non-digital technologies to represent place value in numbers and complete mathematical operations, reflecting on the effectiveness of approaches.	The teacher invites the children to identify technologies that help us to learn Mathematics, encouraging them to consider the range of both digital and non-digital technologies used in Mathematics. The teacher supports the children to recognise that many of the resources they use (e.g., rulers, protractors, balance scales, geoboards) are examples of non-digital technologies. The teacher supports the children to use a non-digital technology (base-ten blocks) to support and deepen their understanding of place value and base ten, and to apply this to mathematical operations (addition and subtraction). The children develop mathematical models for addition and subtraction using base ten blocks, representing and communicating their thinking, as they group and exchange ones/tens/hundreds. The teacher then provides appropriate resources and materials to enable the children to compare this non-digital technology (base ten blocks) with other representations. For example, the children use notation boards, drawings, algorithms, etc. to represent numbers and to use these to add and subtract. The children reflect on their use of different resources and approaches (including the use of non-digital technologies), scaffolded through teacher questioning. For example: • How did you show the number in different ways? What was different/the same about each? • Which approach helped you to see and work with ones/tens/hundreds most clearly? • What helped you to add and subtract most easily? Did this change depending on the numbers you were working with? • Can you explain what you learned to your friend? • How might this help you when you are solving problems in the future?

Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to*	Sample Focus(es) of Learning	Sample Learning Experiences
Stage 1 **Mathematics** **Strand:** Data and chance **Strand unit:** Data explore, interpret and explain data in a variety of ways for a range of purposes. **STE Education** **Strand:** Living things explore, investigate and appreciate the natural world outdoors. Observe, identify and sort plants and animals in their local habitats. Build an understanding of their physical characteristics and the basic conditions they need to survive and flourish. AC, AL, W	Exploring and sorting data collected in the local environment and interpreting and explaining this data to others Identifying and sorting plants and animals from local habitats into groups based on chosen criteria.	The teacher uses the local natural environment as a context for Mathematics learning, supporting children to explore and use data to observe changes over time. The teacher encourages the children to observe living things on a nature walk and gather data of the plants and animals they find (drawings and photographs). The children group their data into sets (e.g., placing photos or drawings into hula hoops) according to criteria of their choice (e.g., plants with flowers, plants without flowers, living things found in the water or found on land). They are encouraged to repeat their data sorting using different criteria. The teacher supports the children to interpret and explain their data with their classmates, e.g., *this group belong together because... (they have six legs, they fly, they are green, etc.).* The teacher builds upon this Learning Experience throughout the year, supporting children to draw on their data to notice and describe similarities and differences in the data across seasons.
Stage 4 **Mathematics** **Strand:** Measures **Strand unit:** Money solve and pose practical tasks to investigate and make informed judgements about transactions and financial plans. **STE Education** **Strand:** Nature of STEM identify and appreciate the key features of Nature of Science, Nature of Technology and Nature of Engineering. Explore and discuss topical STEM issues in Ireland and in the wider world. AC, AL, DL	Making informed and practical judgements in a real-life context (clothes shopping). Investigate the STEM issue of 'fast fashion' and the range of factors that influence people's clothing choices.	The children explore and investigate the emergence of 'fast fashion' as a STEM issue. The teacher prompts and scaffolds discussion on: • The range of factors that influence people's shopping habits (e.g., cost, trends, materials, environmental considerations) • The environmental impact of natural versus manmade materials. They compare the materials and prices of clothing items and consider the 'cost per wear'/replacement cost of clothes, developing models to represent and communicate their learning and understanding. Given budgets for different fictional families, they create a shopping list for clothes for the year that is responsive to their needs. They make informed and practical decisions, identifying the factors that influence their choices, e.g., affordability, sustainability, access, durability, trends. The teacher supports the children to reflect on their task, sharing their observations and learning.

Table 4: Examples of integration within STEM Education

Integration with other curriculum areas

Teachers should prepare for Mathematics Learning Experiences that involve integration with other curriculum areas and subjects. Integrated Mathematics Learning Experiences should be prepared for in parallel and should interact with other curriculum areas and subjects rather than be subsumed into them. Table 5 presents a non-exhaustive set of examples of integration across curriculum areas and subjects. It is not intended as an example of a teacher's recorded preparation. The samples used have been chosen by way of illustration only.

Integration	**Learning Outcomes** *Through appropriately playful and engaging learning experiences, children should be able to:*	**Sample Focus(es) of Learning**	**Sample Learning Experiences**
Mathematics and SEE	**Stage 2** **Mathematics** **Strand:** Shape and space **Strand unit:** Spatial awareness and location visualise and model location using symbolic co-ordinates. **Social and Environmental Education** **Strand:** My locality **Strand unit:** People and places identify, explore and describe significant natural and built features in the local environment. AL, C, M	Using symbolic co-ordinates to represent key features on a simple grid map. Identifying important local natural and built features and representing these on a simple map.	The teacher tasks the children with creating a simple map for tourists visiting the local area, highlighting both natural and built features of interest. Together, they plan a walk of the area, suggesting features of the local environment to be included. They select a way to appropriately describe and record the places they visit (e.g., through writing, sketches or voice recordings). On return to the school, they sketch their map on gridded paper, creating a legend with symbols to represent key features and to distinguish natural and built features. The teacher encourages and supports the children to describe the relative location of each and use this information to plot points of interest on their map.

Integration	Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
Mathematics and PE	**Stage 3** **Mathematics** **Strand:** Measures **Strand unit:** Time compare, approximate and measure time using appropriate units of measurement. **PE** **Strand:** Movement competence **Strand unit:** Movement skills adjust and apply, with increasing confidence, a range of locomotor movement skills such as walking, dodging, mobility wheeling, hopping, running, skipping, jumping and side stepping through a range of the PE activity areas. W, AL, M	Comparing and measuring time in a real-world context (athletics), adjusting strategies to improve speed and efficiency in athletics activities.	Ahead of the annual sports day, the teacher supports the children to explore ways of using Mathematics to improve strategies in athletics activities. For example: • In training for running races over a range of long and short distances, children investigate the advantages or disadvantages of controlled/steady starts versus sprinting starts • In training for a relay race, groups can investigate the time taken to pass the baton (e.g., standing start versus running start) and use this to develop increasingly effective strategies for races. The children use the time data they have collected to make informed, strategic decisions for athletics events.

Integration	Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
Mathematics and Art	**Stage 4** **Mathematics** **Strand:** Shape and space **Strand unit:** Transformation analyse and show how shapes are enlarged on scaled diagrams. **Arts Education** **Strand:** Exploring and creating plan, design, reimagine, create and refine art using design principles (including light, contrast, scale and symmetry) and line, shape, form, colour, tone, texture, space, pattern and rhythm. AL, C, M	Analysing enlarged shapes in artistic contexts and applying enlargements in 2-D art works, applying enhancements for depth, space or focus.	The children explore how the mathematical concepts of enlargement and scale are used by artists to create the illusion of depth, space and perspective in 2-D art works. The teacher provides a range of art works and encourages the children to observe, examine and discuss these, identifying how variations in scale can suggest distance, importance or emphasis within a composition. They also compare art works where scale is deliberately inconsistent or expressive, discussing the visual impact of these choices. The children refine a piece of art (their own, or one inspired by an artist, e.g., Piet Mondrian) by intentionally enlarging shapes and forms within the scene to enhance the sense of depth, space or focus. The teacher engages the children in maths talk throughout the Learning Experiences, drawing their attention to the connections that exist between Mathematics and Art. They discuss the degree of accuracy required in enlargements depends on its purpose and context. For example, artists may intentionally alter scale for expressive or imaginative effect, whereas precise proportions are essential in contexts such as architectural drawings.

Integration	Learning Outcomes *Through appropriately playful and engaging learning experiences, children should be able to:*	Sample Focus(es) of Learning	Sample Learning Experiences
Key Competency: Being a communicator and using language	**Stage 1** **Mathematics** **Strand:** Number **Strand unit:** Uses of number develop an awareness that numbers have a variety of uses. **Language** **Strand:** Writing explore and use the typical text structure and language features associated with a variety of genres. **Strand:** Oral language listen and respond to the aesthetic and creative aspects of language and use language playfully and creatively, and across other languages as appropriate.	Responding to and creating procedural texts drawing on an awareness of ordinal numbers.	The children listen and respond to stories and nursery rhymes that feature ordinal numbers, e.g., Five Little Pumpkins. They follow sequences of actions demonstrated by the teacher using ordinal language, e.g., first put your hands in the air, second clap your hands, third do a silly face. They create their own sequences and share these with classmates. The teacher models the use of ordinal language in everyday procedures. For example, when packing your school bag: • First, you open your bag • Second, you put in your lunchbox • Third, you put in your books • Last, you zip up your bag. The teacher shares this, and other everyday examples, as a procedural text. The children have opportunities to re-order 'mixed up' procedural texts. They engage in shared writing to co-create procedural texts of a simple everyday activity (e.g., brushing your teeth, making a sandwich).

Table 5: Examples of integration with Mathematics and other curriculum areas and subjects

Not all integration can be formally prepared for or anticipated. Everyday integration and 'teachable moments' can also offer valuable and authentic opportunities for children to build connections across the curriculum. In Mathematics, examples of natural and spontaneous integration include:

- Drawing on children's knowledge of fractions to explore the relative length of notes when supporting children to recognise and describe the use of rhythm in Music
- Connecting language used to describe time periods in History (e.g., 'decade', 'century' and 'millennium') with children's knowledge of the base-ten system.

Artificial Intelligence and teacher preparation

Informed, purposeful and ethical use of Artificial Intelligence (AI) can present opportunities to augment and support teachers' preparation for learning, teaching and assessment (*e.g., aiding teachers' understanding of unfamiliar topics, generating and providing feedback on ideas for Learning Experiences or assessment approaches, etc.*). As with all digital tools in education, teachers should be aware of the limitations and risks associated with the use of AI in preparation (e.g., misinformation, bias, hallucinations, *data* privacy, copyright, etc.). Before using tools or programmes which incorporate AI, they should be reviewed for accuracy, alignment with the curriculum, pedagogical relevance and most importantly, safety and trustworthiness.

The management of educational data must be secure and protect the privacy of children, teachers and wider members of the school community. Where a decision is made to use a tool incorporating AI, teachers remain in the lead ensuring the tool supports rather than directs their professional decision-making and judgement.

There are a number of important considerations when exploring the potential use of AI tools to support teacher preparation:

- Does the tool adhere to the relevant policies and guidelines of your school? Is the tool GDPR compliant?
- Will the AI tool or programme meaningfully support teachers' preparation?
- Can you guide and shape AI outputs so they support, rather than replace, teacher professional judgement?
- Are outputs relevant and contextually appropriate to your school setting?
- Before using the output from the tool, have you checked it against other sources and adapted as appropriate?

In all instances, the teacher is responsible for overseeing the output of any AI tools used and ensuring informed, purposeful and ethical use. Further, and evolving, information on the use of AI in schools is available from the Department of Education and Youth's *Guidance on AI in Schools* and through supports provided by Oide and the National Council for Special Education (NCSE).

The learning environment

When preparing for Mathematics, teachers may consider opportunities to draw on or enhance the learning environment in a way that demonstrates the prevalence of mathematics in our lives and the world around us.

Inside the classroom

An indoor environment that is conducive to meaningful Mathematics learning may be characterised by:

- **Opportunities to engage with Mathematics as part of the daily routine.** For example, using visual timetables, clocks and calendars, labelling, organising and categorising, etc.
- **Access and choice regarding resources.** This can support children to engage with and represent their mathematical learning in ways that are meaningful to them.
- **Visibility of mathematical language, symbols, etc.** Mathematics displays or spaces are most useful when they stimulate engagement and discussion. For example, word walls related to current learning, 'Maths Eyes' photographs, maths talk prompts, etc., that can be referred to and interacted with as needed are beneficial.

Outside the classroom

The relevance of mathematics in our world can be further signalled by drawing children's attention to mathematics outside of the classroom. This promotes positive and purposeful engagement with mathematics in the school, home and local environment.

Some Learning Experiences outside the classroom that teachers may consider in their preparation are:

- **Visits to local shops, businesses or amenities** – For example, visiting local shops or restaurants and engaging with menus, labels, money, etc., where appropriate.
- **Maths Trails** – Maths Trails involve a series of mathematical questions or tasks, drawn from the local environment and surroundings, that lead children on a pre-determined route (similar to a Scavenger Hunt). There are opportunities for children to develop their own trails for their classmates or another class.
- **Use of the school yard, garden or sports fields** – For example, applying 'Maths Eyes' to the presence of mathematics in these spaces, using the school yard or fields to estimate and measure longer distances for races, maintaining the school garden through the use of a timetable, monitoring plant growth over time.

 The Primary Mathematics Toolkit contains *Suggestions for the learning environment* for each of the fifteen strand units of the PMC.

Classroom culture

The classroom culture can influence children's learning and their sense of themselves as learners.

In preparing mathematical Learning Experiences, teachers promote a classroom environment that is:

- **Inclusive** – An inclusive environment can be promoted through the provision of choice and flexibility regarding how children engage with tasks, offering opportunities for children to connect their learning to their own lives and interests and providing time and space to provide meaningful feedback on learning. In an inclusive environment, appropriately high expectations are set for all children to support them to reach their full potential.
- **Collaborative** – By providing opportunities for children to work together, children can discuss, reflect on and share their mathematical learning in a social and constructive way. This fosters a learning environment in which children acknowledge and respect each other's opinions and approaches and can engage in productive debate.

- **Playful and engaging** – The curriculum is characterised by playful and engaging Learning Experiences. While this can be promoted through the physical environment, there are also opportunities for teachers to foster a classroom culture that is playful and engaging by drawing on children's interests and curiosities, encouraging creativity and exploration, etc.
- **Supportive of child agency** – Child agency can be fostered in the classroom by identifying opportunities for children to help shape the Focus(es) of Learning and Learning Experiences, to be self-directed and demonstrate independence in their learning and by responding appropriately to their choices and preferences to their learning.

Considerations for Whole-School Curriculum Planning

Schools can:

- Foster a productive disposition towards Mathematics by signaling, promoting and celebrating mathematics through physical learning environments

The Primary Mathematics Toolkit contains support materials and examples of children's learning videos that provide guidance on and suggestions for promoting a learning environment that is inclusive, collaborative, playful and engaging and supportive of child agency.



Parents and families

Establishing and maintaining partnerships between schools and families will enrich children's experience in Mathematics. Schools are encouraged to engage in proactive communication with parents. It is important that parents are made aware of the meaningful contribution that learning in Mathematics makes to their child's overall development.

A partnership approach is grounded in open, reciprocal communication where both teachers and parents play a vital role in supporting children's learning in Mathematics. This approach recognises parents as their child's primary educator, with unique insights into their abilities, interests and needs. Parents' active interest in helping their children to learn and develop in Mathematics is invaluable. They should be assured of the importance and impact of their contribution. It also supports parents to consolidate and extend learning at home.

 The Primary Mathematics Toolkit contains a range of support materials that teachers can draw upon in supporting connections between home and school. These supports focus both on the content of the PMC (e.g., *Suggestions for learning at home* for each strand unit, found in the Directory of strand unit support materials) as well as providing insights into the kinds of Learning Experiences that are optimal for children's learning (e.g., *Reflecting on Maths learning*). Where appropriate, these can be shared with parents to foster a joined understanding of the vision of Mathematics as outlined in the PMC.

Considerations for Whole-School Curriculum Planning

Schools can:

- develop shared approaches for communicating with parents and families that support children's learning and strengthen connections between home and school, while recognising the diverse contexts of families
- signal opportunities to meaningfully involve parents in mathematical learning through school activities and events, e.g., Maths Week.

Examples of how to support children's learning at home

- Raise awareness of day-to-day activities that naturally incorporate mathematics (e.g., shopping, planning daily/weekly schedules, car/bus/train journeys, etc.) and provide suggestions for parents to use these opportunities to support and enhance children's understanding.
- Support parents to make use of toys, books, resources, etc., that are most likely to be readily available in the home or easily accessible (e.g., through a library, in local playgrounds, etc.).
- Provide suggestions for parents that connect with children's mathematical learning or encourage children to share their Mathematics learning at home (e.g., using Maths Journals to inspire rich discussion).
- Draw children's attention to how their learning in school can be applied at home, e.g., their learning in *Measuring* can be applied to cooking and baking activities, their learning in Data can be applied to organising and sorting clothes, toys, etc. at home.

Examples of how to involve parents at school

- Use parent-teacher meetings as an opportunity to discuss and share information regarding the child as a learner, including insights into their attitudes and dispositions towards Mathematics. Consider and share how the child engages with the Elements of the PMC (understanding and connecting; communicating; reasoning; applying and problem-solving). Encourage parents to share their own insights and observations regarding their child's mathematical learning.
- Invite parents to participate in mathematics events, such as Maths trails, Maths quizzes and games, Maths fairs, etc.
- Invite parents to the school to talk about or demonstrate their use of mathematics in the home or at work.
- Share insights into children's mathematical learning through newsletters, the school website, noticeboards, etc.

Resources

When preparing for Mathematics, it is important to recognise that the children, the teacher and the learning environment are the primary resources. Beyond these, all other resources can be considered as tools to support children's learning and their value lies in how well they support children to work towards Learning Outcomes. High-quality physical and digital resources play an important role in supporting children's learning. Children should experience a wide range of resources and are encouraged to demonstrate choice and express preference in selecting and using these, where appropriate.

The following prompts may be useful to consider when selecting resources:

- **Alignment with the curriculum:** Do they support children's progression in learning as described in the PMC?
- **Playful and engaging learning:** Are they motivating for children and reflective of the introductory text to each Learning Outcome in Chapter 5?
- **Accessible:** Are the resources accessible to support meaningful participation for every child?
- **Inclusive:** Are they inclusive of the abilities, interests and needs of the children?
- **Flexible:** Can they be used in different ways and adapted to enact the curriculum and respond to the local school context. Do they support and encourage children's choice in selecting learning activities?
- **Practical:** Are they practical to use, store, and maintain and are they suitable for individual, group or whole-class use?

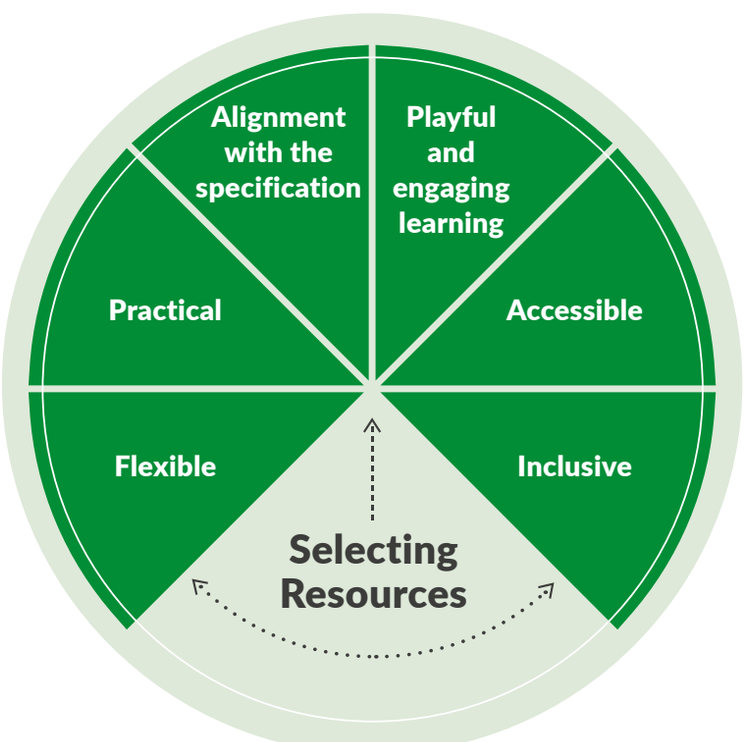


Figure 8: Selecting resources

Human and local resources

Teachers can draw from a diverse range of human resources and local resources when preparing for Mathematics learning, spotlighting how mathematics is everywhere and for everyone. Invite parents or members of the local community to share their use of mathematics in their lives. For example, the use of mathematics in architecture, construction and building trades, cooking and baking, retail, in road signs, etc. Where possible and appropriate, plan for children to visit local businesses or organisations in which mathematics plays a key role.

Classroom and school resources

There are a range of resources that can support playful, engaging and meaningful mathematical learning. These range from 'everyday items' such as buttons and lollipop sticks to more specific or bespoke mathematical resources such as calculators, clocks, scales, etc. The effectiveness of a particular resource is dependent on how and why it is chosen and used to support children's learning.

The use of high-quality resources, including concrete materials, fosters an inclusive and exploratory learning environment in which mathematics is practical, visible and tangible. When preparing, teachers consider children's access to available resources that can help them to make sense of and engage with Mathematics. Importantly, children are encouraged to demonstrate agency in their use of resources, selecting those which support them to learn and to demonstrate their learning in ways that are meaningful to them.

Using calculators or other technology-assisted tools

Preparing for the use of calculators or other technology-assisted tools, as with any other resources, should be considered through the lens of how they support children's learning. Many people have immediate access to calculators or other technology-assisted tools on phones, digital tablets, etc., and as such, it may be useful to support children to be proficient in their use. While it is important that these do not replace other hands-on approaches and strategies, their accurate and efficient use may support and complement children's mathematical learning.

The use of calculators or technology-assisted tools are not specified within Learning Outcomes for a particular stage or stages in the PMC. While calculators are referenced in Mathematical concepts and Progression continua for the strand unit *Sets and operations*, it is important to recognise that the Toolkit is designed to support teachers' agentic decision-making and is not prescriptive. As such, teachers have the professional agency to decide if, how and when calculators and other tools are appropriate for use by the children in their class at a particular stage.

The following examples highlight some instances in which the use of calculators or technology-assisted tools may be appropriate:

- **Mitigating or reducing procedural load** – The use of calculators or technology-assisted tools can mitigate or reduce the procedural load for children where the Focus(es) of Learning are primarily on exploration, creativity, inquiry and modeling, or deepening cognitive engagement with problem-solving. This can also foster an inclusive learning environment, supporting multiple ways for children to engage with mathematical problem-solving.
- **Exploring mathematical concepts** – Calculators and technology-assisted tools can complement children's exploratory and inquisitive nature when learning Mathematics. For example, children can explore, discover and generalise patterns in number, can investigate conversions (with fractions and decimals, currencies, etc.) using calculators. These explorations can stimulate and inform rich mathematical learning and sense-making.

- **Cross-checking / self-assessment** – Calculators and other tools can be used for children to check their own calculations. This process can, and should, foster self-assessment practices, i.e., rather than marking an answer as 'incorrect' following a calculator check, children should be encouraged to review their calculations and identify areas for improvement or correction.

As with other resources, teachers should consider opportunities for engaging with the Elements when preparing for calculator use. For example, children's reasoning skills can be fostered by encouraging them to question calculator outputs (e.g., *Considering the question/problem, my estimate and what I know about mathematics, does this answer make sense? If not, why? What can I try next?*).

Considerations for Whole-School Curriculum Planning

Schools can:

- plan for the provision, organisation and effective use of resources to support continuity, progression and equitable access for all children.

Programmes

Teachers and schools work with the *Primary Curriculum Framework* and the PMC for curriculum preparation purposes. To support curriculum enactment, schools and teachers may also choose to work with programmes to guide their practice, informed by the Whole-school Curriculum Plan. While carefully selected programmes can be of benefit to children's learning in Mathematics, they do not replace the PMC or teachers' professional judgement.

At the heart of the curriculum is the child, their interests, curiosities and prior learning, and the relationships and interactions developed through rich Learning Experiences. Learning, teaching and assessment must therefore remain responsive, playful and engaging. This involves teachers adapting, modifying or supplementing any programme to ensure it aligns with the PMC and meets the needs of the children in their unique classroom context.

Programmes can support learning, teaching and assessment when they:

- are used judiciously to support breadth and balance in children's learning
- are used selectively and purposefully, rather than followed prescriptively
- allow flexibility so teachers can connect the Focus(es) of Learning with children's abilities, interests and needs
- offer opportunities for meaningful playful and engaging learning
- support the enactment of the PMC.

Glossary

Adaptive reasoning	The capacity to use logic to understand, explain and justify one's thinking.
Child agency	Children are active in their own learning and can display their agency by taking the initiative in learning situations, by observing and becoming involved in ongoing events, or by initiating conversations with others.
Conceptual understanding	Understanding of mathematical concepts, operations and relations.
Data	A collection of information or facts, such as numbers, words, measurements, observations or other descriptions.
Disposition	An enduring habit of mind and action. The tendency to respond to situations in characteristic ways.
Learning environment	Describes any space in which children learn or develop their understanding.
Mathematical modeling	Involves using Mathematics to conceptualise a problem or situation and determine meaningful solutions, and in doing so help children formalise their mathematical learning in a way that makes sense to them.
Mathematical proficiency	Consists of the five intertwined and interrelated strands of conceptual understanding, procedural fluency, adaptive reasoning, strategic competence and productive disposition.
Maths talk	A collaborative process where children's thinking, strategies and ideas are discussed, shared and exchanged.
Procedural fluency	The ability to use a variety of mathematical procedures in an effective and efficient way.
Productive disposition	The inclination to see Mathematics as something worthwhile, useful and doable.
Self-assessment	Involves children looking at their own work in a reflective way.
Strategic competence	The skill to devise, represent and solve mathematical problems.
Symbolic co-ordinates	Used to describe the position or location of a point or object.



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