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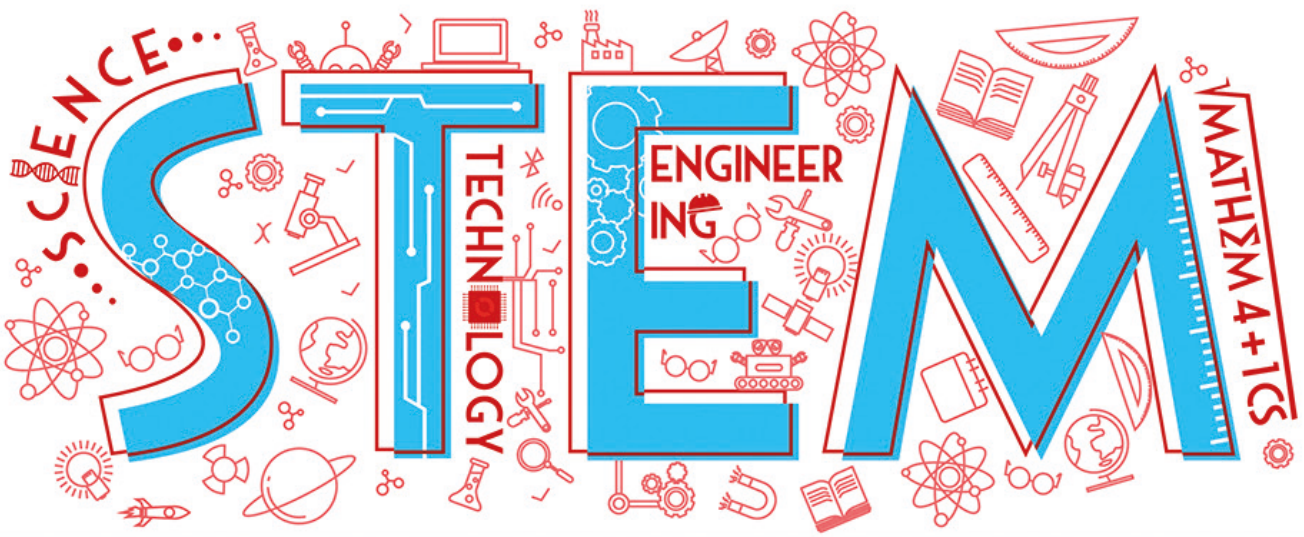
THE PRIMARY



IDEAS BOOK

Engaging Classroom Activities Combining Mathematics, Science and D&T

ELIZABETH FLINN and ANNE MULLIGAN,
with HANNAH THOMPSON

ROUTLEDGE

The PRIMARY STEM IDEAS BOOK

The Primary STEM Ideas Book is designed to promote the integrated teaching of STEM in the primary classroom by providing teachers with lesson ideas for investigations and projects. The statutory requirements of the National Curriculum for science, mathematics and design and technology are comprehensively covered through a variety of practical, stimulating and engaging activities, which have all been tried and tested in the primary classroom. The interrelationship between the STEM subjects is strongly integrated throughout, allowing children's knowledge and skills to develop with confidence in these key subjects through activities that only require easily accessible resources generally found in the classroom.

Written by subject specialists with years of classroom experience teaching STEM subjects, each chapter contains:

- A rationale showing links to the National Curriculum
- Key subject knowledge
- Brief activity plans
- Ideas for supporting higher and lower attaining children
- Follow-up ideas to provide extra inspiration

Including 'how to' guides and other photocopiable resources, this book is perfect for creating integrated lessons, group work and discussions relating to STEM. *The Primary STEM Ideas Book* provides easy to follow instructions and helps spark fresh inspiration for both new and experienced teachers in primary STEM education.

Dr Elizabeth Flinn worked in cancer research before retraining to become a primary science specialist. She taught KS2 and KS3 science in a variety of schools in the state and independent sectors for over a decade. She is now a Lecturer in primary science and design and technology education at Middlesex University in London.

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CHAPTER 1

Introduction to STEM

STEM is widely recognised as the subjects science, technology, engineering and mathematics combined together and taught through an integrated approach. There is growing awareness globally of the importance of STEM education in developing learners as effective problem-solvers who can work constructively as part of a team. The ability to reason mathematically, think critically, solve problems and work collaboratively with others are important skills, sought after by employers today. These are considered by many, including Corlu, Capraro and Capraro (2014), Fitzallen (2015) and Meyrick (2011) to be the key skills of the 21st century.

According to Meyrick (2011), STEM education was first used in the United States as a means of further extending students who were highly talented or who were motivated to deepen their learning. The experience was similar in Australia where STEM opportunities were provided for students who were considered to be gifted in those particular subjects (Fitzallen 2015) and in Turkey where the selection process of schools determined the quality of the STEM education students received (Corlu et al. 2014). Many countries are beginning to see the value of STEM for economic development and are working to improve provision of STEM education in schools. West (2012) believes that countries need to keep up to date with innovation or risk being left behind. He states that 'innovation, particularly through the application of science and technology, is central to maintaining productivity, economic growth, and our standard of living' (West 2012, p. 4). He also makes the point that if a country's capacity for innovation is to be maintained and improved it needs workers who are competent in STEM.

Much of the research on STEM comes from the US and Australia, countries that have carried out research on the benefits of an integrated approach to STEM education on students' learning. Integrating STEM subjects does not mean that all subject disciplines have to be combined. Connections can be made across two or more subjects as long as they are linked 'so that learning becomes connected, focused, meaningful, and relevant to learners' (Smith and Karr-Kidwell 2000, p. 24). Therefore, STEM learning can be seen as interdisciplinary because it involves more than one discipline and the disciplines are interrelated. The curriculum in the primary classroom is particularly suited to this interdisciplinary approach as teachers are expected to teach all subjects and therefore to have good subject knowledge in these subjects. According to Treacy and O'Donoghue (2014), it is important that learners engage in plenty of hands-on group work and have opportunities for enquiry and for discussions throughout. It is also important to introduce STEM activities as early as possible so that learners can develop key skills of problem-solving, critical thinking and mathematical reasoning from an early age. Teaching in this way helps to develop learners' deeper understanding as they experience topics that interest them in real-life contexts (Meyrick 2011). As a result, they are more engaged in their learning and, according to Meyrick (2011), developing these key skills through the teaching of STEM supports pupils from diverse backgrounds so that they have equal opportunities.

There are numerous implications for teachers to consider when teaching integrated STEM activities. The most important of these is their approaches to teaching. More traditional approaches are less effective when it comes to integrating STEM subjects. Teachers need to develop more empowering pedagogies that engage pupils and provide opportunities for enquiry-based learning, creativity and collaborative work (Fitzallen 2015; Meyrick 2011; Stohlmann, Moore and Roehrig 2012). Teachers also need to have a depth of subject knowledge that enables them to feel confident in teaching STEM through an integrated approach. Research by Stohlmann et al. (2012) found that if teachers lacked sufficient subject knowledge in a particular STEM subject then their teaching of STEM would be less effective. Gaps in teachers' subject knowledge or inexperience of teaching a particular subject can lead to teachers doubting their own capabilities. According to Stohlmann et al. (2012, p. 32), 'teachers' content knowledge, experience and pedagogical content knowledge have a large impact on self-efficacy'. Hudson, English, Dawes, King and Baker (2015) noted from their research that 'teaching strategies employed during the STEM lessons facilitated positive attitudes in students to engage with the concepts and the tasks'. The implication for schools that wish to adopt STEM education is that they will need to consider professional development opportunities for teachers so that they receive training in how to develop pedagogic approaches more appropriate for teaching integrated STEM.

Integrated STEM education has implications for curriculum planning as the school curriculum structure may not have the flexibility to allow for this approach to teaching. Teachers may also need support with planning in a more interdisciplinary way, which will differ to discrete subject planning. More time will be needed initially for teachers to plan in this way until they become more familiar and confident with this approach. Resourcing is a further consideration when teaching STEM due to the increase in hands-on practical activities. This may impact on the space available for storage as well as available funding as more resources are needed.

The benefits of STEM education are evident from research by Fitzallen (2015), Meyrick (2011) and Stohlmann et al. (2012), who agree on the positive impact it has on pupils' learning. Meyrick (2011) explains how problem-solving approaches can improve learners' critical thinking skills as well as their understanding of process and their ability to communicate effectively. Stohlmann et al. (2012) discuss how learners can become better problem-solvers who are self-reliant and have a more positive attitude to school. Corlu et al. (2014, p. 75) believe that the 'overarching goal of STEM education is to raise the current generation with innovative mindsets'.

Research carried out in the US by Xie, Fang and Shauman (2015) indicates that although test scores are on a par for boys and girls when comparing mathematics and science, there is a gender gap when it comes to girls continuing STEM to third-level education and beyond. Sax, Kanny, Riggers-Piehl, Whang and Paulson (2015) attribute the lack of engagement of older girls in STEM subjects to their lack of confidence in mathematics rather than their mathematical ability. However, they believe that this may change in the future with more women being attracted into all STEM fields.

This book is designed to promote the teaching of STEM in the primary classroom. The activities are suitable for learners from Year 1 to Year 6 and can be adapted and simplified as necessary for a specific year group. The activities within the chapters can be taught as part of a half-term topic, a STEM week or as individual lessons. The interrelationship and connection between the subjects come across strongly in the activities and in the skills needed to complete them. The activities are all hands-on, as recommended by Treacy and O'Donoghue (2014) and there are obvious opportunities for children to engage in group work and discussion. The chapters contain a number of enquiry questions that children have to investigate through trial and improvement or by adopting a systematic approach. As discussed earlier, it is not necessary to have all the STEM subjects combined for every activity and there are some examples within the chapters where the focus is on two subjects rather than all four. The

resources used for each activity are easily accessible and many are everyday objects found in the home. This should make it easier for teachers in terms of cost and storage. The layout of each activity should make planning less time consuming as it contains many pieces of key information that can be copied and pasted onto a lesson plan.

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CHAPTER 2

How to use this book

All the activities in this book have been tested by children aged 6 to 11. The authors, illustrator and children have had a great deal of fun designing and testing everything and it is our hope that we have provided enough information and guidance to allow many more children and adults to enjoy and be inspired by the activities. STEM is engaging, challenging and relevant and we think these activities reflect this.

ORGANISATION

This book is organised into themed chapters although each activity can stand alone. All the activities in one chapter could be used for a whole-school STEM event or one or two activities from different chapters could be chosen to support a particular science or mathematics topic.

Each activity has a suggested Introduction and Plenary along with activity notes, but there are always other ways to introduce and summarise the activities.

We have endeavoured to keep resources as simple and cheap as possible. If specialist resources are recommended for an activity then, where possible, an alternative resource is also described. Because the resources are easy to find, the activity ideas can also be used as home-based projects, when children and adults work together to produce a product for a special event or competition at school.

CURRICULUM LINKS

Each activity has links to the Primary National Curriculum for mathematics and science. These links (taken directly from the 2013 Primary National Curriculum document) can be used to support learning in both or either subject. Every activity has the most relevant Primary National Curriculum links highlighted and these are summarised in the Curriculum map at the end of this chapter. There may be other links too, do not feel constrained by our suggestions!

All activities include planning, designing and making skills linked to the design and technology (D&T) curriculum. An opportunity to evaluate designs and products is included in the suggested plenary sections for the activities. If an activity matches a specific D&T technical knowledge theme, then this is indicated in the Curriculum links section and on the Curriculum map.

Activities are usually suitable for either KS1 or lower/upper KS2. Where possible, we have tried to match the mathematics and science curriculum links to the same key stage or year group. Occasionally this has been impossible due to the rather limited curriculum for science at KS1. However, by using the support or extension suggestions, the activities can be simplified for younger children or made more challenging for older children.

PHOTOCOPIABLE RESOURCES

Many activities have associated photocopiable guides designed for use by children. The text of the guides requires good reading skills so each guide has been illustrated carefully, to show each step in the process as clearly as possible. In many guides, Professor Mouse (Figure 2.1) is also present, demonstrating what the children should do.

Figure 2.1 Professor Mouse

STEM OR STEAM?

There is an increasing interest in STEAM: combining the STEM subjects with the arts. For some of the activities in this book there is a clear arts link, but for others it may be more difficult to make a connection. Table 2.1 suggests some ideas for relevant links.

Table 2.1 Suggested STEAM links

Chapter	*Suggested STEAM links*
3	Timepieces have been present in homes throughout the centuries. Many are beautifully decorated or sculpted. Visit an historic house or museum to see examples of this.
4	The activities in this chapter are clearly linked to art.
5	All activities about transport link closely to geography. For a more artistic link, consider the design of the postage stamps from different countries. These often reflect important events, locations or people of the country.
6	While out in woodland, make some large natural art. Using branches, dead leaves and rocks, the children can create splendid, temporary artworks. Look at the work of Goldsworthy and Long for examples.
7	The children could explore the idea of being a castaway or lost in the wilderness through drama. The 'Whistles' activity, with its focus on pitch and volume has strong links to the music curriculum.
8	Think about how a rather dull, brown substance is made attractive to eat. Discuss the use of colour, shape and texture. Look at the packaging and think about the decoration, arrangement and use of eye-catching logos and pictures.
9	Flight and space travel have inspired many musical compositions. Listen to Holst's *Planets* suite or the atmospheric soundtrack to the film *Apollo 13*.
10	Focus on interesting and exciting architectural designs when building with triangles. Think about the ways architects have solved the problem of holding a roof up and creating an inspiring, beautiful space under it.

CURRICULUM MAP

The year groups for which the activity is most suited, in terms of curriculum requirements, are shown for mathematics and science:

- The mathematics topics are grouped under the Primary National Curriculum headings where they relate specifically to the activities in the chapter. Understanding of number and calculations are not referred to specifically as they are intrinsic to all aspects of mathematics. However, in Chapter 4 some components of number have been highlighted.
- Mathematical reasoning skills are embedded into most of the activities.
- Science topics are grouped under the Primary National Curriculum headings. For simplicity, the various materials topics have been grouped together so that Y1: Everyday materials; Y2: Uses of everyday materials; Y4: States of matter; and Y5: Properties and changes of materials are all included under the 'Materials' heading. The Y1 topic seasonal changes has been included under the heading 'Space'.
- Working scientifically skills such as making observations, taking measurements and recording data are embedded into many of the activities.
- The working scientifically enquiry themes – Fair testing (FT); Observing over time (OT); Identifying and classifying (IC); Pattern seeking (PS); and Researching using secondary sources (R) – are identified where appropriate.
- Occasionally, an activity has no direct link to the mathematics or science curriculum. However, children will have the opportunity to extend their learning in a particular area. This is marked on the Curriculum map with a star (*).
- D&T curriculum requirements have been grouped under six broad headings: Structures; Mechanisms; Food; Textiles; Electronics; and Control. These show the technical subject knowledge covered. Apart from the Electronics and Control sections (KS2 only), the activities meet the requirements for both key stages. All activities require planning, making and evaluation skills.

The Curriculum map has been compiled for the Primary National Curriculum in England but using the Curriculum map in combination with the more detailed links given in each chapter, it should be possible to map the activities to other curricula. All the activities in the book can be linked to International Primary Curriculum topics and many are compatible with the Common Core for Math and Next Generation Science Standards used in the United States.

Table 2.2 Curriculum map for mathematics

	Mathematics							
	Number: fractions	**Number: multiplication and division**	**Ratio and proportion**	**Algebra**	**Measurement**	**Geometry – properties of shapes**	**Geometry – position and direction**	**Statistics**
Sundials					1, 2, 3		5	
Water clocks		3			1, 3, 4			
Candle clocks		3			3, 4			3
Gravity clocks					3, 4			3
Alarm clocks					2, 3			
Tracking the sun					2			2
Are you *Vitruvian Man*?	2, 3		6		2, 3			2, 3
Fibonacci and the golden rectangle				6		3, 4		
Symmetry in nature						2, 4		
Number patterns				6				
3-D shape bubbles						2, 3, 6		
Cargoes						2, 4		
Egg race					2, 5			
Defying gravity					2, 4, 5			2, 5
Post a crisp					2			
Animal antics		3			2			2
Is fastest best?					2, 3, 5			2
Cable cars					2			
Pea mazes					1, 2		2	2
Living walls						1, 3		
Meet a tree					1, 2, 4, 5	6		
Grow a meal					2, 3, 5			
Plants for building					2	5		2
Sunflower race					2, 3, 5			2, 4

(*continued*)

Table 2.2 (Cont.)

	Mathematics							
	Number: fractions	**Number: multiplication and division**	**Ratio and proportion**	**Algebra**	**Measurement**	**Geometry – properties of shapes**	**Geometry – position and direction**	**Statistics**
Heliographs						5		
Buoyancy aids					5, 6			
Wind chill					2			2, 4, 5
Whistles								4, 5, 6
Compasses							*	
Beach-combing					2			
How strong is chocolate?					3, 4			4
Percentages	5		6		3			
Chocolate wrappers						2, 6		
Flat-pack building						6		
Making chocolate					2, 5			
Market research								2, 3
Paper planes					2, 6			5, 6
Jet engines					2, 3			
Rockets					2			
Catapults					2			
Parabolas					2	5		6

	Mathematics							
	Number: fractions	**Number: multiplication and division**	**Ratio and proportion**	**Algebra**	**Measurement**	**Geometry – properties of shapes**	**Geometry – position and direction**	**Statistics**
Payloads					2			
Who forged the cheque?								
Chain reaction								
Building with triangles						1, 2, 3, 4, 6		
Sorting machines								
Packing puzzles							2	
Makey Makey								