# The Arts and Mathematics

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Keywords: mathematics, reasoning, problem-solving, creativity, thinking, arts, geometry.

Chapter objectives

This chapter will help you to:

- To explore a range of ways to develop links with mathematics and the arts
- To know how many aspects of the arts are inspired by mathematics
- To draw on artists who have used mathematics as their inspiration for their work.
- To introduce the mathematics in nature and how patterns are used to develop mathematical thinking
- To draw upon geometry as an art form to develop patterns, inspired by nature
- To share worked examples of how mathematics and the arts can be developed in primary schools.

***Teachers Standards and ITE Core Curriculum Content x 3 per chapter max – This is really hard to pin down as there is a LOT of content in the CCF , so please just do the 'best fit' - we are hoping to get a good spread of different aspects of this across the book ;***

| **TS1 Set high expectations which inspire, challenge and motivate pupils** | |
|---|---|
| **CCF: *LEARN THAT*** | **CCF: *LEARN HOW TO*** |
| 6. High-quality teaching has a long-term positive effect on pupils' life | • Seeking opportunities to engage parents and carers in the education of their children (e.g. |

| | |
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| chances, particularly for children from disadvantaged backgrounds. | proactively highlighting successes) with support from expert colleagues to understand how this engagement changes depending on the age and development stage of the pupil. |

| **TS1 - Set high expectations** which inspire, motivate and challenge pupils | |
|---|---|
| **CCF: *LEARN THAT*** | **CCF: *LEARN HOW TO*** |
| 1. Teachers have the ability to affect and improve the wellbeing, motivation and behaviour of their pupils.<br><br>5. A culture of mutual trust and respect supports effective relationships | Communicate a belief in the academic potential of all pupils<br><br>Create a positive environment where making mistakes and learning from them and the need for effort and perseverance are part of the daily routine. |

| **TS3** Demonstrate good subject and curriculum knowledge | |
|---|---|
| **CCF: *LEARN THAT*** | **CCF: *LEARN HOW TO*** |
| 1. A school's curriculum enables it to set out its vision for the knowledge, skills and values that its pupils will learn, encompassing the national curriculum within a coherent wider vision for successful learning.<br><br>5. Explicitly teaching pupils the knowledge and skills they need to | ● Deliver a carefully sequenced and coherent curriculum<br>● Providing an opportunity for all pupils to learn and master essential concepts, knowledge, skills and principles of the subject.<br>● Ensuring pupils have relevant domain-specific knowledge, |

| | |
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| succeed within particular subject areas is beneficial. | especially when being asked to think critically within a subject. |

| **TS4** Plan and teach well-structured lessons | |
|---|---|
| **CCF:** ***LEARN THAT*** | **CCF:** ***LEARN HOW TO*** |
| 1. Effective teaching can transform pupils' knowledge, capabilities and beliefs about learning.<br><br>2. Effective teachers introduce new material in steps, explicitly linking new ideas to what has been previously studied and learned. | ● Plan effective lessons<br>● follow expert input - by taking opportunities to practise, receive feedback and improve<br>● model effectively<br>● Stimulate pupil thinking and check for understanding |

1. ***Research / theory focus (breakout box to highlight a research/ theory source)***

***Introduction***

Mathematics has a long-established heritage in the arts however this is very rarely discussed or featured in the primary mathematics curriculum. One of the major factors driving this is the dense curriculum and demands on teachers' time to deliver all aspects, leaving little time to plan and deliver activities that make connections with the richness of mathematical ideas and their links to the arts.

At the heart of mathematical thinking lies the notion of patterns. Our lives are driven by patterns, we may not think about them explicitly but implicitly they are there, e.g. our daily routines are determined by patterns. Pupils as young as nursery age, know the structures of their school day and hence the pattern to their day. Goldin (2002, p. 197) simply describes mathematics as "the systematic description and study of pattern." Mathematics is the science of patterns and Steen (1988, p. 616) describes mathematicians as people who seek patterns "in number, in space, in science, in computers and imagination". The idea of mathematicians seeking imagination by Steen (1998) is an important one as the imagination drives

creativity and creativity drives the arts. Therefore, pupils in primary schools would highly benefit from a range of approaches in building mathematical understanding through the different art forms thus fostering the thread of creativity through their mathematics learning (Mann, 2016).

The work of Jerome Bruner (Bruner, 1966) is a vital component of how pupils develop their mathematical thinking. His modes of representation from the Concrete, Pictoral to the Abstract (CPA) forms the foundations of how mathematics is taught not just in the English mathematics curriculum but also around the world. The English mathematics curriculum is designed and developed with these underpinning principles. Therefore, when pupils start to learn mathematics they are given opportunities to experience it through a range of sensory approaches using manipulatives and the physical space to develop understanding E.g. music can be used to build mathematical understanding through the use of patterns within a sequence of music; dance sequences can be developed by giving pupils instructions on the number of movements involved within a set sequence. Furthermore, rhyming patterns are used regularly to develop language but they have a distinctive meter pattern shaped by the repetition of the number of syllables used to develop the rhyme. This informative early concrete, sensory experiences support the holistic development of a pupils' insight into the beauty of mathematics and the involvement of a range of arts to facilitate this insight.

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**Practical Power**

Did you know that the now embedded mathematical resource of Cuisenaire rods was developed by a primary teacher who created the resource to make the learning of mathematics a more hands-on, sensory experience? George Cuisenaire was a music and mathematics teacher at a school in Thuin, Belgium. Whilst teaching music he noted that pupils benefited from learning music through an instrument, thus making the learning to be a practical experience. Furthermore, listening to musical keys on a keyboard for e.g showed the relational distance between the different key thus helping pupil understanding. George Cuisenaire decided to develop a set of ten, different colour rods that similarly represented numbers and therefore supported his pupils' visual understanding numbers 1-10 and therefore enhanced their mathematical understanding (ATM, 2020).

***>>>>>>(Chapter 11 figure 1 Shahzaib, a reception pupil, (age 5 years) creating images and patterns with Cusinaire Rods.) image here***

Cuisenaire rods are introduced to pupils as young as reception class. Pupils are encouraged to use the rods to make patterns and the handling of the rods supports pupils to become familiar with the different sizes and thus being immersed in what the relational relationship between the sizes of the rods. This builds an early foundation for them to move on to using the rods for later mathematical reasoning.

Reflective question

How do you use Cuisenaire rods for your mathematics learning? How can you use the rods to build creativity within your mathematics teaching?

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2. ***Examples of good practice: case studies/ interviews/ personal stories***

Geometry is an area of mathematics that artists have been fascinated with and used across millennia to develop their work. Artists such as Wassily Kandinsky, Sol

Lovett, Maurits Cornelis Escher, Annie Albers, to name a few have all taken inspiration from geometry to develop their work.

Islamic art, as a discipline, uses the principles of geometry, to develop intricate patterns. The principles of the golden ratio and how this applies to symmetry is commonly applied to develop intricate geometric patterns. The Alhambra Palace in Granada, Spain has complex geometric patterns, developed by artisans both on tiles as well as stone and wood carvings. The palace was the inspiration for Maurits Cornelis Escher's work. Escher used the principles of tessellation, where different shaped tiles can fit together without overlapping (Bachmeier, 2016). He studied the shapes and patterns and used them to develop what we know as his distinctive art form. The mathematical principles of tessellation can be used to develop a project with upper Key Stage 2 pupils. This can be further enhanced by sharing the work of Escher and for pupils to develop a final piece in the style of Escher (Tesselations.org, 2020). The boxed feature below provides a step by step sequence (illustrated by photographs) to develop this project.

**<<<< boxed feature**

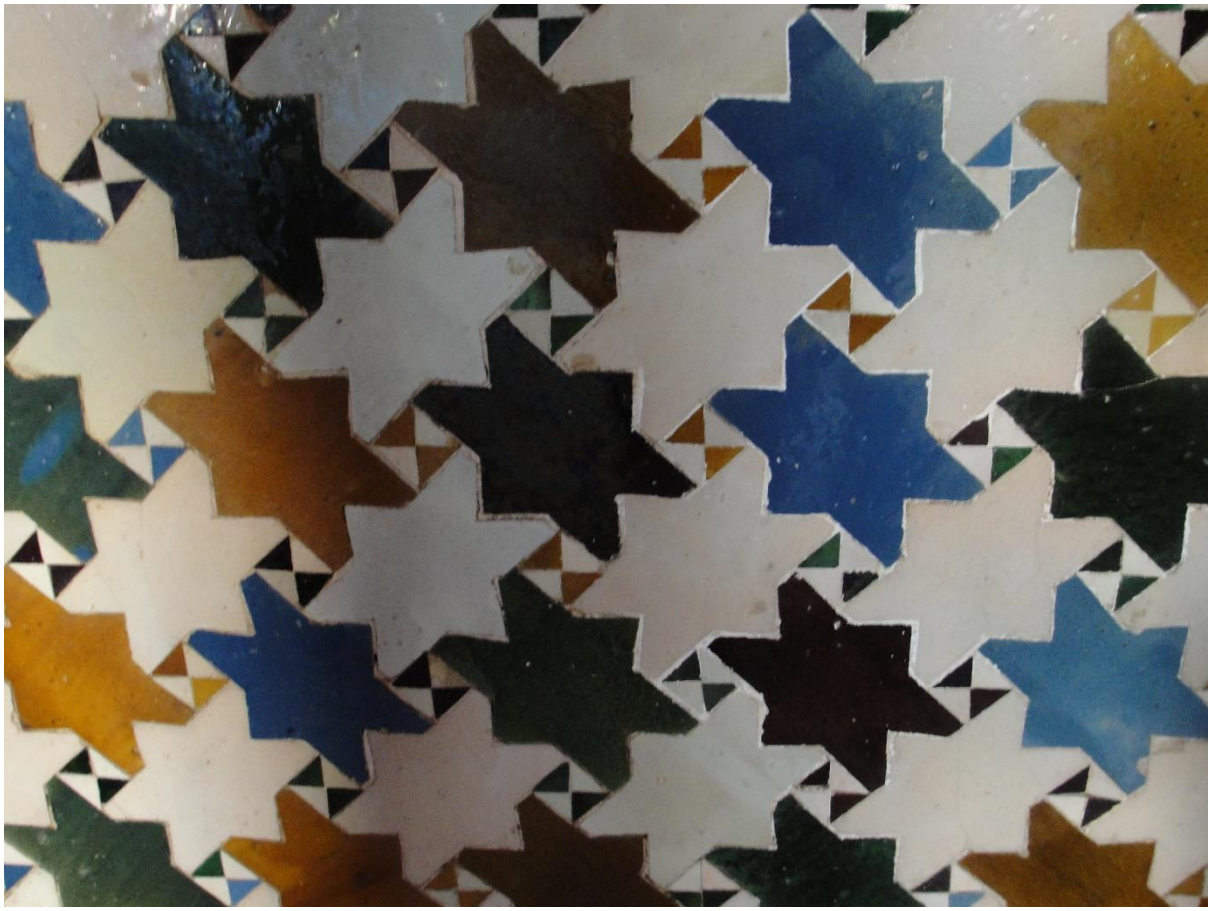
Run your own tessellation project

Different shapes can be introduced to pupils to examine and decide which shapes tessellate and pupils can be encouraged to look at the similarities and differences between the shapes, hence exploring properties of shapes that tessellate.

Follow these steps to success for developing this activity:

1: Share a range of images from The Alhambra Palace:
https://www.alhambradegranada.org/en/info/galleryofphotographs/tiles.asp

Feel free to copy these images to share with pupils to facilitate the next stage of this activity.



***>>>>>>(Chapter 11 figure 2 A photograph tessellating patterns were taken at The  Alhambra Palace) image here***

***>>>>>>( Chapter 11 figure 3 A photograph of tessellating patterns, taken at The Alhambra Palace,) image here***

2: Encourage pupils to see the patterns and where the principles of tessellation occur.

3: Share some images of Escher's work (https://mcescher.com/gallery/symmetry/ https://mcescher.com/gallery/mathematical/) and get pupils to compare and contrast the work with the images shared of tessellating patterns from The Alhambra Palace. Images of the work of Escher can be easily accessed via the internet.

4: Pupils to design their artwork representing tessellating patterns in the style of Escher. (see figure 5 for sequence).

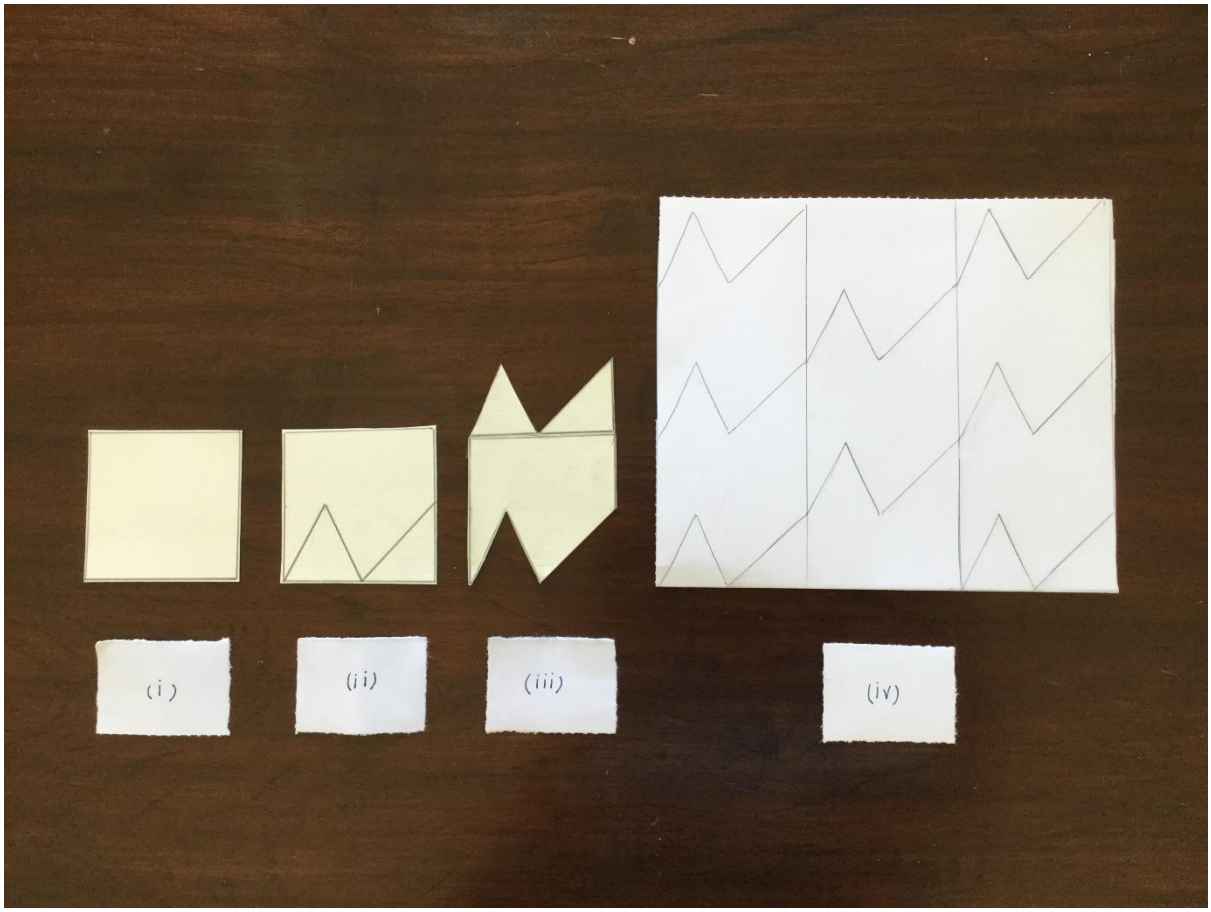
i) Pupils to start with a shape that will tessellate-e.g. a square.

ii) Cut out a shape from one side of the square and fix it to the other side.

iii) Now you are ready to use this as a template to develop your tessellating pattern.

iv) Use the template to develop your pattern.

**>>>>>>( *Chapter 11 figure 4* using principles of Escher to develop own piece of art. By N Majid) *image here***

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**A Case Study of a trainee teacher developing the arts with her year 5 pupils**

Saffron was a trainee teacher, undertaking a PGCE. She was on her final teaching practice. Her confidence in teaching the arts was rooted in her own experiences of learning in school.

The class had developed a project on India as part of their summer learning. Saffron had been given the task of teaching a sequence of lessons incorporating

aspects of geometry and art. Although she perceived herself to be a reflective learner, open to new ideas, this task had created a sense of anxiety. The anxiety stemed from firstly having a perception of not fully understanding the nature of the links between the subjects of mathematics and the arts and secondly, ensuring that the subject could be taught with an element of diversity inorder to create an inclusive space for all leaarners. After careful thinking, research and planning Saffron developed a sequence of lessons that represented and developed the ideas of geometry and art, with a starting point from the pupils.

Saffron firstly asked pupils to bring along items from their homes which represented aspects such as patterns, shapes, imagery etc from their culture. These could be artefacts or an image from the internet. This formed the basis of the first lesson where experiences were shared of how patterns, shapes were evident in artefacts from around the world and their cultural significance. The rest of the lessons used the stimulus of the Taj Mahal and the geometric patterns within the Taj Mahal. Pupils studied the patterns and looked out for the properties of the patterns, e.g. tessellation, size, mirror symmetry. Saffron shared a range of patterns from the Taj to get pupils to develop a shared collage of their work. Pupils used their knowledge and understanding of mathematics learning and the understanding of the patterns at the Taj Mahal and developed their unique geometric pattern. Their patterns showedmirror symmetry and were designed to go onto a 16cm x 16cm tile. This then led to pupils using the ideas to develop their pattern that they added to a ceramic tile and used their tiles to create their final piece. The final pieces of art was a collaborative effort by Saffron's class and went on the 'Wall of Diversity' representing the community of learners as individuals and as a community.

An additional aspect of work that Saffron went on to develop was looking at the tradition of dance in India and how a sequence of dance moves were developed by the students to perform in a class assembly. The mathematics drawn out by Saffron was the development of sequences in pentagonal and hexagonal patterns and

repetition of these patterns in seqiuences of two and three.  Principles of traditional music, musical instruments, the patterns in each sequence of dance moves and bringing the class together in a collective dance sequence enabled Saffron to incorporate aspects of the arts, mathematics and cultural diversity into her learning. She was observed whilst showcasing the assembly to her parents and was highly commended by the headteacher and the parents.

Reflective Question

Reflection: How would you tackle a challenging situation when you are asked to develop a sequence of learning incorporating the arts into your teaching? What would be your starting point? How would you involve your learners and incorporate their heritage in developing the learning?

Analysis

Confidence develops with experience and a belief that there is value in what you are trying to achieve. This value is driven by knowing that the approach to teaching in a creative way, using the arts not only expands on ones own development but enables learners to understand the interconnections between different subjects. How wonderful to bring the gift of understanding that some of the fundamental principles driving artists have mathematics as their root. Furthermore, enabling exploration at this level broadens insight into different cultures and thus developing engagement on meaningful,  diverse activities and learning opportunities within a primary classroom.

***The early years and Key Stage 1- Mathematical development through the Arts.***

Pupils in the Early Years are immersed in their environment and encouraged to make links that help develop their understanding holistically. Nature trails form a key part of pupils appreciating their spaces and linking learning through these walks creates a fun way of facilitating all aspects of learning. Mathematical development can be accelerated through this immersion with an emphasis on

observation, questioning and discussion of what is observed through these immersive experiences in nature. Montague-Smith, Cotton, Hansen, and Price (2018) discuss the nature of learning mathematics and the importance of making connections and understanding the relationship between the connections being made. Hence, supporting pupils from a young age to see how their living and learning spaces enable them to see patterns, creatively and the connections between those patterns is a vital step to the early development of creativity developing mathematical ideas in a connected way.

The outdoor space is a rich environment for learning and there are many opportunities to link mathematics and mathematical thinking whilst being immersed outdoors. One obvious way in is the use of maps and developing mapping skills with primary age pupils. ("The Royal Geographical Society ", 2020). Mapping skills allow pupils to engage in a range of ways in the outdoor space. Firstly, reading maps is a key skill and developing this skill early in primary schools supports pupils with their problem solving skills and special reasoning. Pupils in primary schools are introduced to maps by sharing different types to maps to understand that maps come in a range of representation, e.g. globes, world maps, Ordanance Survey maps, local town maps, school site map etc. Allowing pupils to explore the nature of maps and understanding the scales of maps is the first step of learning the language of maps and how they are pivotal tools for navigation.

Activity to explore the outdoor space and mapping skills

Pupils in year 1 can explore an outdoor space familiar to them,  such as part of a playground, local woodlands and then encouraged to observe what is in the space and how this could be represented in a map. The four compass points are also introduced at this point and pupil are encouraged to work in pairs to give eachother directions to follow. This can be extended into a treasure hunt, to create a fun way of exploring the area in detail in order to gather details. The pair who finds the

most objects wins a prize. Allow the pupils to take photographs of the area being explored, these photograps can then be used as a whole class follow up activity to draw a map of the area explored. This map would contain key objects seen and the compass directions.

**A short introduction to the boxed feature here?**

**Developing outdoor trails are an excellent way to incorporate mathematical thinking with primary pupils. These can be exploratoty where pupils are encouraged to look out for items along a walk that they collect and the collection of items can be used to develop mathematical thinking (figure 5, activity 1 below) or they can be more structured and incorporate a trail where questions have already been set and placed in an outdoor space that you would like the pupils to explore, E.G. if pupils in year 2 have been working on fractions, one of their learning activities could be to develop a set of questions for an outdoor mathemetics trail. This will not only provide a purpose for the learning happening in class but also have the added value of exploring the outdoor environment near the end of the unit by taking part in the mathematics trail. Both activities have merits in supporting mathemical learning in a creative and imaginative way for primary pupils.**

**<<<< boxed feature**

Activity 1: Nature trails are a fun and creative way for pupils to make sense of their surroundings. Whilst on a walking trail, pupils can be encouraged to pick leaves and other natural materials, under the strict guidance of an adult. During the walking questions such as comparison of the sizes of materials, shapes of materials gathered can be asked to facilitate thinking. These items are then brought back to their learning space and firstly used to further discuss the properties of the shapes. Further mathematics can be developed by grouping the objects using criteria such as colour, size, shape etc. The final piece, with all the material gathered, would be a class collage. This can be added on a large piece of paper such as a paper roll to be displayed in the class.

***>>>>>>( Chapter ? figure 5***These two images illustrate the development of a nature trail collage, created by Shahzaib, aged 5.**)** ***image here***

Activity 2: Using the outdoor space, pupils can be encouraged to create a dance sequence and share the number of steps within the sequence. This would work well in pairs so that pupils develop their language as well as listening skills. When one pupil is sharing their sequence the other listens and follows the instructions to try out the dance sequence. The activity is then repeated to ensure both pupils have a go at developing the dance sequence of their partner. The activity can be scaled up by asking two pairs to join up and share their dance sequences and then be challenged to blend their dance moves together. The blending would involve the pupils to think about the sequencing of their moves and how this would play out with the merging of two distinct set of sequences. The activity can be further extended with a creative and problem-solving element by providing a set of rules, that represent sequences of numbers, and pupils to use these rules as they wish to develop their dance sequence. E.G. in your dance move today, we would like to see four hops, fiver jumps, two shuffles, six steps etc. Pupils would then create their sequence with these criteria but how the sequence is arranged is up to each individual or pair of pupils. Pupils could be further challenged to develop a dance sequence to set piece of music where a set of numercal criteria are shared. This creates a more open ended activity, thus fostering further creativity, reasoning and problemsolving.

Reflection: Think about the activities you do regularly that develop mathematics and the arts? How do you visualise the use of the outdoors to facilitate the learning of the arts? What ideas will you take away from these examples to develop with your pupils?

**<<<< end of the boxed feature**

***Ofsted Deep Dive- What is ofsted looking for in understanding and the teaching of mathematics and the Arts. The intent of the curriculum and the implementation of this.***

Intent

Have a universal look through your mathematics provision and reflect on where the arts already exist and how this can be further enhanced within the teaching and learning of mathematics. What aspects of incorporating the arts within the teaching and learning of mathematics links to issues of cultural capital (Bourdieu, 1973) and hence furthering aspirations and opportunities for pupils?

Implementation

Where is the evidence within your long term planning of a creative approach, incorporating the arts within your mathematics provision? How can your mathematics leaders and school leaders support in the weaving of the arts within the teaching and learning of mathematics? What type of professional learning opportunities can be implemented in your school to facilitate the teaching of mathematics through the arts?

(Bruner, 1966; Polya, 2004; Skemp, 1989)

Impact

What is the impact of this work on pupil outcomes How do you measure this?

**<<<< end of the boxed feature**

## *3. Chapter summary*

This chapter has aimed to demonstrate how creativity within mathematics can be utilised to incorporate the teaching of mathematics through the arts. It is rare to see the marriage of the arts and mathematics yet, at the heart of mathematical thinking, is the notion of creativity and making connections. The chapter has supported you to understand how key theories links with mathematical knowledge and understanding and the connections with the arts. There has been an emphasis on practical, measurable activities that can be developed with little resource

implication to support teachers to achieve high gains in learning outcomes. The chapter has intended to inspire the reader to look at mathematics more holistically so that the learning approaches can facilitate the promotion of the arts.

## 4. *Further reading/resources:*

Escher In Het Paleis. https://www.escherinhetpaleis.nl/about-escher/?lang=en The Escher Museum website in the Haigue, Neatherlands.

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