STEAM Tales

Lesson plans

Maryam Mirzakhani

Co-funded by the European Union

Maryam Mirzakhani's biography

Credits: Stanford University. Immediate source: https://www.tehrantimes.com/news/417810/Standford-University-commemorates-Maryam-Mirzakhani

Maryam Mirzakhani, born in 1977 in Tehrān, Iran, was an Iranian mathematician who made history in 2014 as the first woman and the first Iranian to win the prestigious Fields Medal. She was recognised for her exceptional work on the dynamics and geometry of Riemann surfaces and their moduli spaces.

As a teenager, Mirzakhani won gold medals at the 1994 and 1995 International Mathematical Olympiads, achieving a perfect score in 1995. She earned a B.Sc. in mathematics from Sharif University of Technology in 1999 and a Ph.D. from Harvard University in 2004 for her groundbreaking dissertation on hyperbolic surfaces. Her career included positions as a Clay Mathematics Institute fellow, assistant professor at Princeton University, and professor at Stanford University. Mirzakhani's research focused on hyperbolic geometry, where Euclid's fifth postulate does not apply, leading to unique properties like infinite parallel lines through a fixed point.

Mirzakhani's pioneering contributions advanced understanding of complex mathematical spaces and, long after her death in 2017, from breast cancer, continue to inspire mathematicians and minorities worldwide.

Co-funded by the European Union

Lesson plan 1

Flexible geometry	
Keywords: geometry, shapes, manipulation, playdough, 2D and 3D structures	
Duration: 50-55 min	**Age:** from 7 to 9 years old
Place: Classroom	**Related STEAM areas:** **E** (Engineering): Exploring how shapes are used in building and construction **A** (Art): Creatively combining and manipulating shapes **M** (Math): Analysing the properties, comparisons and combinations of geometric figures
Description	This experiment helps children explore 2D and 3D shapes through hands-on manipulation using playdough and craft sticks, allowing them to construct, alter, combine and manipulate geometric figures. This activity fosters their understanding of geometric properties, shape flexibility and spatial awareness.
Learning objectives	At the end of this experiment, children will be able to: • Visualise and construct basic 2D and 3D shapes. • Understand how shapes can be manipulated,

	stretched and compressed to form new shapes. • Have a deeper understanding of geometric properties and their relationships. • Develop creative thinking and problem-solving by combining different shapes to create more complex figures. • Practice motor skills and precision, such as forming straight lines and figures with playdough.
Connection to the female role model	The experiment connects to the work of Maryam Mirzakhani, who made significant contributions to geometry, particularly in understanding the properties of complex shapes and spaces. The activity introduces children to geometry through playful experimentation, highlighting how the manipulation of shapes can lead to new mathematical discoveries, much like Mirzakhani's work.
Individual or group	Individual or group activity (in pairs to collaboratively build complex shapes)
Safety	Supervision is recommended when children are using craft sticks or toothpicks.
Materials	☐ Playdough/play-doh (at least 100g per child)

	☐ Craft sticks or toothpicks (at least 20 per child)
Lesson plan	
Introduction (10 min)	Begin by asking children about the shapes they already know and where they have seen them in real life (such as triangles, squares or circles in buildings or objects: road signs, TV screens, dish plates or sports balls, etc.). Show a few videos of geometric shapes being created with playdough, to capture their curiosity and provide a visual reference for the activity: • "Build 2-D shapes with toothpick and play-doh clay activity |learn sides and vertices |Geometry" by Kids_project & more • "3-D SHAPES with PLAY DOUGH and TOOTHPICKS I Fine & Visual Motor Sensory Skills I OT Teletherapy" by OT Closet Bring a connection to Maryam Mirzakhani's story: "Do you remember in the story where Maryam worked on geometric shapes, the ones that twist and turn? Why do you think she started being interested in how shapes work and interact with each other?"

Research question/hypothesis (5 min)	"How can we manipulate and combine basic shapes to create new, more complex structures?" Children should be encouraged to give their answers, even the wrong ones. All opinions should be included and not discarded right away, even though the teacher knows they are not right. The experiment will serve to answer the research question, mimicking the scientific method.
Step-by-step instructions (30 min)	**Step 1: Forming basic shapes** Children can use playdough to create tubes or balls, which represent the sides or vertices (corners) of various shapes. They then insert sticks or toothpicks into the dough to form geometric figures like triangles, squares and circles to visualise and manipulate basic 2D structures. **Step 2: Manipulating Shapes** Children can twist, squish or stretch the playdough shapes to explore how their properties change. For example, they can turn a square into a rhombus or stretch a circle into an oval, playing with the flexibility and variability of geometric figures.

	Step 3: Combining shapes
	
	Children combine different shapes using the playdough and sticks to form more complex figures. For example, they can join two triangles to create a diamond or combine multiple shapes to explore new structures.
	
	Step 4: Exploring 3D shapes
	
	Children can manipulate the shapes beyond 2D by constructing three-dimensional shapes like cubes, pyramids and prisms using additional dough and sticks. They can experiment with expanding, compressing or stacking these shapes to play around with volume and depth.
	
	Specific instructions: To create 3D shapes, children can follow these steps:
	
	• **Forming basic 2D shapes:**
	  ○ Roll the playdough into small balls or tubes to represent the vertices (corners) of the shapes.
	  ○ Use craft sticks or toothpicks to form the straight edges of the shapes. For instance, for a square, use four playdough balls at each corner and connect them with four sticks or toothpicks to

STEAM Tales

form the edges.

  - Note that some shapes will not need toothpicks, such as a circle or oval, and edges can be made with playdough but may not be straight or solid enough to uphold each other when combined into 3D shapes.
- **Forming a cube**:
  - **Step 1**: Make 2 squares by rolling the playdough into balls for the corners and using toothpicks to connect them.
  - **Step 2**: Position the two squares parallel to each other, one on top of the other.
  - **Step 3**: Use toothpicks to connect the parallel corners of the two squares, forming the vertical edges (corners) of the cube.
- **Forming a pyramid**:
  - **Step 1**: Start by creating 4 triangles of the same size with playdough balls as the corners and toothpicks as the edges.
  - **Step 2**: Place one triangle flat on the surface to form the base.
  - **Step 3**: Connect the other triangles by joining their edges to the base using toothpicks, with the top of the triangles meeting to form the peak.
  - A more complex variant can be made of a

	tetrahedron (or square-based pyramid) by using a square as the base and adding 4 triangles. • **Forming a prism:** ◦ **Step 1**: Start by creating 2 identical rectangles using playdough balls for the vertices (corners) and toothpicks for the edges. ◦ **Step 2**: Position the two rectangles parallel to each other, just like the squares for the cube. ◦ **Step 3**: Connect the corresponding corners using toothpicks to form the vertical edges (corners) of the prism. Other variants and more complex shapes could be created by combining multiple 2D shapes and playing with angles, but they require more advanced understanding and precision, making them more difficult to create or manipulate for young children.
Source	**Example videos:** "Build 2-D shapes with toothpick and play-doh clay activity |learn sides and vertices |Geometry" by Kids_project & more "3-D SHAPES with PLAY DOUGH and TOOTHPICKS I Fine & Visual Motor Sensory Skills I OT Teletherapy" by OT Closet

	Additional resources: "Preschool Geometry: Building Shapes with Playdough" by Schooltime Snippets "Geometry with playdough and toothpicks" by Teach Me Mommy
Conclusion (5 min)	Review the research questions and discuss how the manipulation and combination of shapes led to new forms. Explore and develop what the children learned about the properties of different geometric figures by providing the names of certain shapes and observing how their sides or structures evolved.
Explain the experiment (5 min)	"Today, we explored how shapes can be created and changed using playdough and craft sticks. We started with basic shapes like triangles, circles and squares, which you see everywhere around you, and then saw how we can stretch, bend and combine them into more complex shapes. By creating 2D shapes, which are flat, and 3D shapes, which have height and depth, we learned how engineers and architects use geometry to build structures. Now you can understand the properties of shapes and how they fit together to form new and interesting designs."

The science behind	This experiment introduces children to the fundamental concepts of geometry. By using playdough and craft sticks to manipulate shapes, children can visually and physically interact with geometric concepts, helping them understand the structure and properties of various shapes and learn about geometric properties, spatial relationships, and the concept of volume in three-dimensional space. It also illustrates how engineers and mathematicians like Maryam Mirzakhani use geometric principles to solve real-world problems. This experiment encourages spatial reasoning, a key skill in mathematics, engineering and architecture. **Why:** Geometric shapes are present in every aspect of our lives in various ways and are the foundation of many different fields, such as architecture, engineering and art. Learning geometric shapes is essential for children as it builds foundational skills in spatial awareness, problem-solving and logical thinking. By recognising and manipulating shapes, children develop the ability to understand how objects fit and relate to each other in space, which is crucial for daily activities and future learning in subjects like math and science. Geometry

	also fosters creativity by introducing concepts of symmetry, proportion and pattern, which are important in art and design. Understanding shapes also prepares children for more advanced math, such as calculating area, volume and angles, while also connecting abstract concepts to real-world applications they encounter in everyday life, like architecture and nature. **How**: • **Basic geometry**: The experiment begins by creating simple 2D shapes (like triangles, squares and circles), which allows children to visualise the sides and vertices (corners) that define these figures. Understanding how shapes are formed from simple components is essential for grasping more complex geometric concepts, making an abstract topic clearer and more concrete. • **Manipulating shapes:** By stretching, squishing or bending the shapes, children can see how the properties of geometric figures change. For example, turning a square into a rhombus or stretching a circle into an oval demonstrates that shapes are not fixed but can be transformed by altering their dimensions and angles.

	• **3D geometry:** Once they understand the basics of creating shapes, children can create cubes, pyramids and prisms using the same materials. This helps them understand volume, depth and the relationship between different geometric shapes in space. By constructing 3D objects, they gain a tactile sense of how shapes can be stacked, expanded or compressed in three-dimensional space. **Historical overview:** Geometry has its roots in ancient civilisations, particularly in Egypt and Mesopotamia, where early humans used geometric principles to build structures like the pyramids and ziggurats. The study of geometry as a formal branch of mathematics was further developed by Euclid in the 3rd century BCE, whose work, "Elements", remains a foundation of geometry education. The understanding of 3D geometry is crucial in fields like architecture and engineering, where structures are designed and built in three-dimensional space. The experiment helps children appreciate how geometric principles are applied in real-world construction, from the design of buildings to the creation of everyday

	objects. This experiment integrates mathematical concepts with hands-on learning, helping children understand the properties of geometric shapes and how they can be manipulated. By moving from 2D to 3D shapes, children gain a deeper understanding of geometry's practical applications in the world around them while also developing their spatial reasoning skills.

Lesson plan 2

The Mathematical Mosaic Keywords: geometry, shapes, patterns, mosaic, creativity	
Duration: 70-85 min	**Age:** from 6 to 9 years old
Place: Classroom	**Related STEAM areas:** **E** (Engineering): Applying geometric principles to create structurally sound designs **A** (Art): Expressing creativity through patterns, colours, and shapes **M** (Maths): Practising the use of geometric shapes, symmetry, and patterns
Description	This experiment allows children to cut and manipulate coloured paper into various shapes and arrange them into repeating or organised patterns, exploring spatial awareness, precision and symmetry. This activity enhances their understanding of geometry, pattern recognition and creative design.
Learning objectives	At the end of this experiment, children will be able to: • Visualise and cut basic shapes in paper.

	• Understand how shapes can be assembled and arranged into repeating patterns. • Arrange shapes while meeting certain expectations such as maintaining symmetry or alignment. • Develop spatial awareness by experimenting with how different shapes fit together in a mosaic. • Apply creative thinking by designing visually appealing patterns using colours and geometric concepts. • Practice fine motor skills by cutting, positioning and gluing shapes with precision.
Connection to the female role model	The experiment connects to the work of Maryam Mirzakhani, who made significant contributions to geometry, particularly in understanding the properties and behaviour of complex shapes in curved spaces. The activity allows children to manipulate geometric shapes, discover patterns and explore symmetry, fostering an understanding of how mathematics shapes both art and the world around us, much like Mirzakhani's work.
Individual or group	Individual or group activity
Safety	Supervision is recommended when children are using scissors.

Materials	☐ 1 white poster (A3 format) per child ☐ Alternative: 1 A2 poster for group collaboration or 1 A1 poster for class display ☐ Papers of different colours (at least 4 per child) ☐ Scissors ☐ Glue
Lesson plan	
Introduction (10 min)	Begin by asking children about the shapes they already know and where they have seen them in real life (such as triangles, squares or circles in buildings or objects: road signs, TV screens, dish plates or sports balls, etc.). Show a few videos of paper mosaics to capture their curiosity and provide a visual reference for the activity: • "Crafts for Kids Ep 2– Paper Mosaic Art" by Footsteps 4 Life • "[Arts] Easy paper mosaic" by Chau Vu • "DIY Mosaic Art: Islamic Geometry/ Seni Mozek Geometri Islam" by Walk Of Life WOL Bring a connection to Maryam Mirzakhani's story: "Do you remember in the story where Maryam worked on geometric shapes, the ones that twist and turn? Why

	do you think she started being interested in how shapes work and interact with each other?”
Research question/hypothesis (5 min)	“How can we use shapes to create beautiful and organised patterns? And how does that relate to what mathematicians do when studying geometry?” Children should be encouraged to give their answers, even the wrong ones. All opinions should be included and not discarded right away, even though the teacher knows they are not right. The experiment will serve to answer the research question, mimicking the scientific method.
Step-by-step instructions (30 min)	**Step 1: Cutting the shapes** Children cut the coloured paper into various geometric shapes such as squares, triangles, hexagons and other polygons. For younger children: if cutting gives children trouble, the teacher can assist them or even prepare various shapes in advance. **Step 2: Arranging the shapes** Children arrange the cut shapes on a large poster, aiming to create a repeating pattern without any gaps or overlapping areas. To do so, ask them to place the

	pieces so that they repeat the same shapes, touch each other properly and fit into each other like a puzzle without getting over or under each other. They can explore how different shapes fit together, creating a visually pleasing mosaic, forming symmetric or mandala patterns or filling in pre-drawn illustrations, exploring spatial awareness and pattern recognition. **Step 3: Adding complexity** The teacher can add an extra layer of difficulty by asking children to ensure that no two shapes of the same colour are touching or by creating a symmetrical pattern. **Step 4: Gluing the shapes** Once satisfied with their arrangement, children glue the shapes onto the poster so they can properly observe their design and appreciate its components.
Source	**Example videos:** "Crafts for Kids Ep 2- Paper Mosaic Art" by Footsteps 4 Life "[Arts] Easy paper mosaic" by Chau Vu "DIY Mosaic Art: Islamic Geometry/ Seni Mozek

	Geometri Islam" by Walk Of Life WOL **Additional resources:** "Math Mosaic Art" by 123shomeschool4me "Geometry and mosaics" by PCG Geometry "Sensory Wall Mosaic Art for Kids = Math Learning for Kids" by Mama Smiles
Conclusion (5 min)	Review the research question and discuss how arranging and combining geometric shapes helped create structured patterns. Encourage children to reflect on how different shapes fit together and how symmetry and repetition influence design. Reinforce their learning by identifying specific shapes, their properties, and how their arrangement led to new geometric compositions.
Explain the experiment (5 min)	"Today, we explored how geometric shapes can be combined to create patterns, just like mathematicians and artists do. We started by cutting out simple shapes like triangles, squares, and hexagons, then arranged them to form repeating patterns and symmetrical designs. By doing this, we discovered how different shapes fit together without leaving gaps and how symmetry makes designs more balanced and visually

	appealing. Just like Maryam Mirzakhani used geometry to explore patterns in mathematics, you used shapes to build your own mathematical mosaics. This experiment helps us see how math is not just about numbers but also about creativity, aesthetics and structure, which we find in art, architecture, and even nature!"
The science behind	This experiment introduces children to fundamental geometric concepts by allowing them to cut, arrange, and combine shapes into structured patterns. By engaging in hands-on exploration, children develop an understanding of how geometric figures relate to each other in space, reinforcing key principles of symmetry, pattern recognition, and spatial awareness. Through arranging and manipulating shapes, children discover how **tessellation** works – how shapes fit together without gaps or overlaps – just as mathematicians study geometric structures to understand the relationships between forms. This connects to the work of Maryam Mirzakhani, who explored how shapes behave in curved spaces and encourages spatial reasoning and pattern recognition, which are key skills in mathematics, engineering and architecture.

	Why: Geometric shapes are present in every aspect of our lives in various ways and are the foundation of many different fields, such as architecture, engineering and art. Learning geometric shapes is essential for children as it builds foundational skills in spatial awareness, problem-solving and logical thinking. By manipulating and assembling shapes, children develop the ability to understand how objects fit and relate to each other in space, which is crucial for daily activities and future learning in subjects like math and science. Geometry also fosters creativity by introducing concepts of symmetry, proportion and pattern, which are important in art and design. Understanding shapes also prepares children for more advanced math, such as calculating area, volume and angles, while also connecting abstract concepts to real-world applications they encounter in everyday life, like architecture and nature. **How:** • **Basic geometry**: The experiment begins with children cutting out basic geometric shapes such as squares, triangles and hexagons. This hands-on activity helps them recognise the defining

properties of these shapes, including sides, vertices, and angles. Understanding how shapes are formed from simple components is essential for grasping more complex geometric concepts, making an abstract topic clearer and more concrete.

- **Pattern formation and spatial awareness**: By arranging their cut-out shapes into patterns, children explore tessellation – how shapes fit together without leaving gaps. This introduces them to spatial reasoning and helps them understand how geometric principles are used in architecture, design and nature.
- **Symmetry and precision**: Children are encouraged to create symmetrical designs and follow rules like ensuring that no two same-coloured shapes touch or that the pattern is fully symmetrical. This challenges them to think critically and develop creative problem-solving skills to manage balance, proportion, and repetition, key concepts in both mathematics and art.

Historical overview: Geometry has its roots in ancient civilisations, particularly in Egypt and Mesopotamia, where early humans used geometric principles to build structures like the pyramids and ziggurats. The study

	of geometry as a formal branch of mathematics was further developed by Euclid in the 3rd century BCE, whose work, "Elements", remains a foundation of geometry education. Mosaics, an artistic application of geometry, have been used for thousands of years to decorate floors, walls, and ceilings. The earliest mosaics, found in Mesopotamia around 3000 BCE, were made of clay cones embedded in walls. The Greeks and Romans refined the art, creating elaborate geometric patterns and scenes using tesserae (small coloured stones or tiles), which originated the concept of tessellation. From the 8th century onward, Islamic art and architecture, further advanced geometric mosaics. Islamic craftsmen developed intricate, repeating tessellations that followed complex mathematical rules, reflecting symmetry, balance, and infinite pattern possibilities. These designs not only beautified buildings but also demonstrated deep mathematical knowledge, foreshadowing concepts later explored in modern geometry. In the 20th and 21st centuries, mathematicians like Maryam Mirzakhani expanded the study of geometry

	by exploring hyperbolic surfaces and moduli spaces – fields that, like mosaics, investigate how shapes fit together in different spaces. The Mathematical Mosaic experiment connects to this rich history by allowing children to explore patterns, symmetry, and spatial awareness through hands-on geometric design, linking ancient craftsmanship with real-world construction and modern mathematical thinking. By manipulating and assembling shapes into aesthetic patterns, children gain a deeper understanding of geometry's practical applications in the world around them while also developing their spatial reasoning skills.

#steamtales-project

www.steamtales.eu

Co-funded by the European Union

STEAM Tales (KA220-HE-23-24-161399) is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the Nationalen Agentur im Pädagogischen Austauschdienst. Neither the European Union nor the granting authority can be held responsible for this.

MIND Mittelhessisches Institut für Nachhaltigkeit und Diversität · GoINNO · U.PORTO · cesie · LogoPsyCom