STEAM Tales

Lesson plans

Domitila de Carvalho

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Domitila de Carvalho's biography

A picture of Domitila de Carvalho (Source: Associação de Professores de História)

Domitila Hormizinda Miranda de Carvalho was born on the 10th of April 1871 in Santa Maria da Feira and died on the 11th of November 1966 in Lisbon. She was a Portuguese doctor, professor of mathematics, writer and politician. After completing secondary school with excellent results, Domitila became the first Portuguese woman to enter university in 1891, thanks to the intervention of her mother and a high school teacher with the Rector of the University of Coimbra. There she graduated with honours in mathematics (1894) and in philosophy (1895) and obtained a doctorate in medicine in 1904.

She worked as a doctor in Lisbon helping tuberculosis patients, and later as the first female mathematics teacher in Portugal at the D. Maria Pia High School (the first Portuguese secondary school for girls) until her retirement, serving as the school's dean between 1906 and 1912. She wrote several books of verse. In 1934, Domitila was one of the first three women to be elected to parliament in Portugal, where she advocated for women's right to divorce and the introduction of compulsory courses in general hygiene and childcare in girls' secondary schools to reduce infant mortality.

Lesson plan 1

Exploring geometry and architecture with the Tower challenge Keywords: Geometry, architecture, polyhedra, stability, shapes	
Duration: 70 min	**Age:** from 8 to 9 years old
Place: Classroom	**Related STEAM areas:** **M** (Mathematics): Exploring geometric shapes and measurement principles. **A** (Art): Understanding form, structure, and design in creating stable shapes. **E** (Engineering): Applying architectural principles of stability by testing the strength of shapes.
Description	This experiment allows children to explore the connection between geometry and architecture by building towers using spaghetti and clay. The experiment is divided into two parts: in the first part, children will create shapes individually, whereas in the second part, they will create the towers as a group to help each other.
Learning objectives	At the end of this experiment, children will be able to:

	• Identify and construct basic 2D and 3D shapes, such as squares, triangles, pyramids, and cubes. • Recognise which shapes create stronger, more stable structures. • Build and measure a stable, tall tower using spaghetti and clay.
Connection to the female role model	Domitila de Carvalho was the first woman in Portugal to graduate in mathematics and a pioneer in science education. Her work emphasised the value of mathematical thinking in solving real-world problems. This experiment reflects her legacy by encouraging children to apply mathematical concepts like shapes, measurement, and stability to create strong, functional structures.
Individual or group	Individual and group.
Safety	This activity is safe for children. However, they should still be supervised when breaking spaghetti apart and informed not to put them in their mouth.
Materials	☐ 2 bags of dried spaghetti ☐ Moulding clay or Play-Doh ☐ A measuring tape or a 50cm-ruler ☐ Pencil cases from the children (with pens and pencils inside)

	☐ Access to the Internet to show tall structures like buildings and bridges (optional).
Lesson plan	
Introduction (10 min)	Start by asking children if they have ever looked at a tall building and wondered how it stays standing when the wind is blowing hard. After hearing their responses, tell them that for that to happen, architects and engineers use special shapes to make buildings strong and stable and that they will be exploring some of those shapes in the experiment.
Research question/hypothesis (5 min)	Ask children a few questions to awake their curiosity. For instance: • What do you think will make a stronger base for a tower — a square or a triangle? • Do you think we can make towers made of spaghetti as tall as the table? Or will they fall apart? Encourage children to share their ideas and opinions. Write down their predictions on the board to revisit during the reflection phase.
Step-by-step instructions (45 min)	**Step 1: Building Simple 2D Shapes** Ask the children to make simple shapes (such as squares and triangles) using spaghetti as the edges

	and clay or Play-Doh as the connectors. For stronger and more resistant shapes, suggest them to break the spaghetti into shorter pieces or to put more pieces of spaghetti together. **Step 2: Creating 3D Structures** Once they are comfortable with creating 2D shapes, encourage them to convert them into 3D shapes, like pyramids and cubes. **Step 3: Testing Shape Strength** Ask children to place their pencil cases on top of the shapes to test which bases are the strongest. Explain that in real-world architecture, a strong foundation helps support the weight above it, making the structure stable. **Step 4: The Tower Challenge** Divide the children into teams of 4-5 members and ask each team to build the base of their tower using either triangular or square shapes. From there, set a timer for 20 minutes and challenge each team to build the tallest tower. Suggest them to build it from the

	floor rather than over the table, as this will give them more control over its height. **Step 5: Measuring and Evaluating the Towers** Once the time is up, help each team to measure their tower with rulers or measuring tapes to find the group who was able to build the tallest structure that is still standing.
Source	"Leo Labs Engineering Challenge – Towers with Pasta" by Brain Chase "Toothpick Tower: Engineering Design Challenge" by Ms. B the Science Teacher
Conclusion (5 min)	To end the lesson, gather the children for a final discussion to reflect on what they learned from the experiment and share their thoughts. You can use the following guiding questions: • What did you learn about shapes today? • Which shapes were the strongest for building towers? • What would you change about your tower if you could build it again? • Where else do you see strong shapes like triangles in the real world?

	The goal of this experiment was to understand how the shapes we use in construction affect the strength and stability of structures. On the other hand, the shapes we see in many tall structures are not just decorative, but play a crucial role in how strong and stable a structure is. If possible, show images of real-world examples like bridges, skyscrapers, and famous towers (like the Eiffel Tower) that use triangles and strong bases for stability. This helps children see how the principles they used in class are applied in real life.
Explain the experiment (5 min)	By building and testing different shapes, children learned that triangles distribute weight more evenly, making them one of the strongest shapes used in construction. This is why the towers they built with triangular shapes were less susceptible to falling apart. Squares are naturally less stable than triangles because their sides can shift or collapse under pressure. If children built a tower with one cube stacked on top of another, it would likely wobble or fall. However, adding diagonal spaghetti pieces inside the vertical faces of each cube significantly increases

	its stability. This is because the diagonals divide the square faces into smaller triangles, which are much stronger and more rigid. This concept is applied in real-life structures like bridges, roofs, and famous towers like the Eiffel Tower in which triangular shapes provide strength and stability (if possible, show children different tall structures so they can understand the concept better). While many modern buildings have a "cubical" appearance, these are stable because they are reinforced with diagonal supports or internal frames that form triangles within the square structure.
The science behind	The stability and strength of structures are rooted in the geometry of shapes. The triangle is considered one of the strongest and most stable shapes in construction. This is because, unlike squares or rectangles, triangles cannot be deformed without changing the length of their sides. When force is applied to a triangle, the weight is distributed evenly along its three sides therefore making it strong and rigid. This principle is why triangles are a key component in bridges, domes, and trusses.

Squares and rectangles, on the other hand, are more flexible. If you push on one side of a square, it can easily turn into a parallelogram unless it is reinforced with diagonal supports. By adding a diagonal support, the square is effectively divided into two triangles which makes the structure more stable.

Another critical concept in engineering is load distribution. When force is applied to the top of a structure (like placing a pencil case on top of a tower), the load must be transferred down to the base. If the structure's base is strong, the load is spread out evenly, and the tower stays upright. If the base is weak, the load shifts, causing the structure to collapse. This is why buildings often have wide, heavy bases or foundations to support the weight above them.

This process is used by architects and engineers worldwide to create stronger, safer, and more efficient structures.

Lesson plan 2

Understanding how breathing works with Lung Models Keywords: respiratory system, lung function, diaphragm, air pressure	
Duration: 55 min	**Age**: from 6 to 9 years old
Place: Classroom	**Related STEAM areas:** **S** (Science): Introducing basic concepts of respiratory physiology, such as lung function and the mechanics of breathing. **E** (Engineering): Exploring simple models that represent complex biological functions.
Description	In this experiment, children will create a simple lung model, which will allow them to see how the diaphragm's movement causes the lungs to expand and contract. This experiment will help them better understand how breathing works by visualising the process of inhaling and exhaling.
Learning objectives	At the end of this experiment, children will be able to: • Describe the role of the diaphragm in the breathing process. • Explain how the expansion and contraction of the lungs are related to changes in air pressure.

	• Build a model that represents the basic functions of the lungs and diaphragm.
Connection to the female role model	Domitila de Carvalho was the first woman in Portugal to graduate in mathematics and a pioneer in both science education and health reform. Her work as a doctor focused on improving public health, particularly in maternal and child care. This experiment focuses on the human respiratory system which is a key aspect of health education and a topic that Domitila had to master too.
Individual or group	Individual or in group.
Safety	This experiment is safe with proper supervision from teachers. Children should be instructed to handle the pre-cut plastic bottles carefully, as the edges of the cut sections may be sharp. Additionally, teachers should cut the balloons.
Materials	☐ 1 transparent, pre-cut, top part of a plastic bottle (one per child/group) ☐ 2 small balloons of different colours, one for the lung, one for the diaphragm (one per child/group) ☐ An image of the respiratory system ☐ Scissors to cut the balloons (for teacher's use)

	☐ Tape (optional)
Lesson plan	
Introduction (10 min)	Show the children an image of the respiratory system and point out the diaphragm and the location of the lungs. Then, proceed to inform that when we breathe, these two important parts of the body work together so that the air goes in and out of our body. Finally, tell them that this experiment will allow children to better understand the breathing process.
Research question/hypothesis (5 min)	Ask: "What do you think happens to the lungs when we breathe in and out?" Encourage children to guess what they think happens to the size of the lungs and the movement of the diaphragm during breathing.
Step-by-step instructions (30 min)	**Before the experiment**, the teacher should prepare the plastic bottle by cutting off its top part. Teachers should also prepare the image of a respiratory system. **Step 1: Preparing the Chest Cavity**

	Give each child or group of children a pre-cut bottle and inform them that it will represent the chest cavity where the lungs are located. **Step 2: Creating the Lung** Give two balloons (one of each colour) to each child or group of children and ask them to gently stretch them. Then, ask them to place one of them inside the bottle in a way that the balloon's opening is hanging outside of the bottle's opening while the rest of the balloon is inside. Finally, ask them to stretch the balloon's opening around the bottle's opening so that it is stuck. To make it more secure, you can tape the balloon's opening around the bottle's opening. This balloon will represent the lung. **Step 3: Making the Diaphragm** The second balloon will be used to create a diaphragm. Tie the opening of the balloon and cut a small part of the opposite side of the balloon. The part with the knot needs to be big enough so that it can be stretched to cover the opening in the bottom of the bottle. **Step 4: Demonstrating Lung Function**

	Finally, ask the children to gently pull and release the balloon with the knot (representing the diaphragm) at the bottom of the bottle. As they pull, the lung balloon inside expands, and as they release, the lung balloon deflates. **Step 5: Connecting to the Respiratory System** Explain to the children how this experiment relates to our respiratory system and compare it to the respiratory system image.
Source	"Make a Lung Model – STEM activity" by Science Buddies "Lungs STEAM" by Gateway Region YMCA
Conclusion (5 min)	Ask children to describe what happened when they pulled and released the diaphragm. Once some thoughts have been exchanged, explain how the experiment simulates breathing: when we inhale, the diaphragm moves downward, creating space for the lungs to expand; when we exhale, the diaphragm relaxes, and the lungs deflate. Ask them to place their hands on their lower ribs and breathe in deeply. They will notice how their chest expands as the diaphragm moves down. Then, ask

	them to breathe out and feel how their chest deflates as the diaphragm relaxes and moves up. This physical connection will help them better understand how the diaphragm and lungs work together.
Explain the experiment (5 min)	When pulling down on the balloon at the bottom (the diaphragm), the balloon inside (the lung) is filled up with air. That happens because pulling the diaphragm down creates more space inside the bottle, just like how the diaphragm moves down in the chest when we breathe in. This extra space reduces the air pressure inside, and air from outside rushes in to fill the space. This is why our lungs fill with air when we breathe in. When letting go of the diaphragm, the space inside the bottle gets smaller, hence pushing the air out of the balloon inside. This is just like when the diaphragm in the body moves up, making our chest smaller and pushing air out of our lungs when we breathe out.
The science behind	Breathing happens because of changes in air pressure inside the chest. The diaphragm is a muscle under the lungs that moves up and down to control these changes. When we breathe in, the diaphragm moves down, making more space inside the chest. This extra

	space lowers the air pressure inside, so air from outside your body moves in to fill the lungs. This is how we inhale air. On the other hand, when we breathe out, the diaphragm moves back up which reduces the space inside the chest. This increases the air pressure, and therefore the air in the lungs is pushed out. The movement of the diaphragm is what controls when we breathe in and out.

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