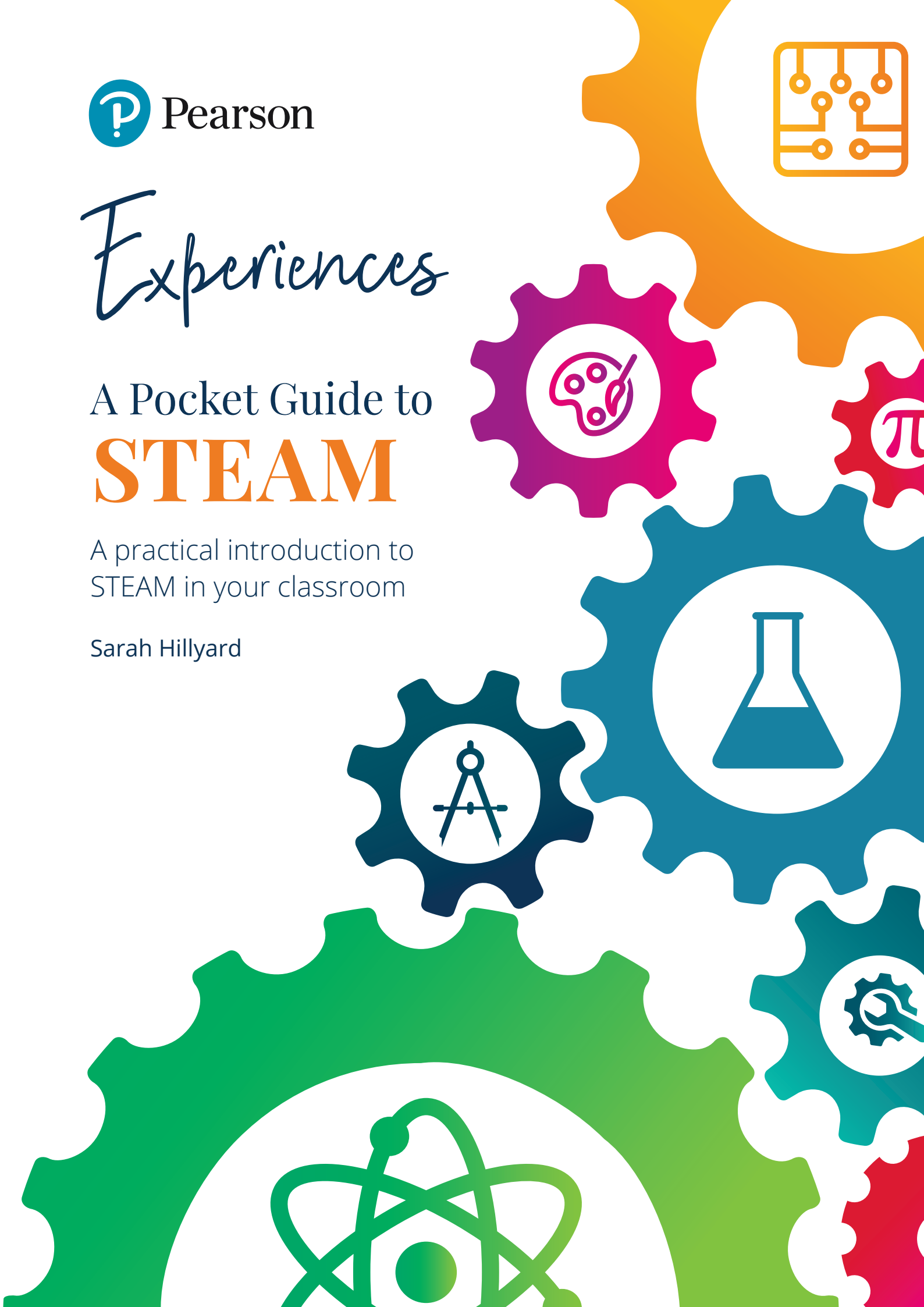
Pearson

Experiences

A Pocket Guide to STEAM

A practical introduction to STEAM in your classroom

Sarah Hillyard



About the author

Sarah Hillyard is British, born in Spain and lives in Buenos Aires, Argentina.

She's a teacher trainer, materials writer and author. She is also tutor on NILE (professional development programmes for EL teachers and trainers, both face-to-face and online) online course *Teaching English in Pre-Primary Education* and delivers webinars and face-to-face talks at conferences and schools.

She was a teacher and coordinator at pre-primary level before becoming a consultant for bilingual schools in Argentina, helping teachers plan and reflect upon their lessons. She feels observing lessons and discussing feedback openly with teachers is the highlight of consultancy, as it is the best way for teachers to improve their techniques and strategies.

She is also a singer and has been an actress, spending two years travelling with The Performers, Theatre in Education Company, and feels this has influenced the way she sees education. The Arts have always been present in her life and her teaching.

Her mission is to encourage teachers to gain confidence in teaching more than just language by applying STEAM as an integrated approach to teaching and learning. The pre-primary and primary Pearson courses she has co-authored involve STEAM lessons in every unit. She believes in teaching the whole individual and developing skills that are transferable to real life situations.

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See more of Sarah's work and read her blog at **https://shillyard.wordpress.com** or **www.linkedin.com/in/sarah-hillyard-13698565**

What is STEAM?

STEAM is an acronym that stands for Science, Technology, Engineering, Art and Design, and Maths. Rather than teaching all of these as separate subjects, STEAM interweaves them into language lessons. In a classroom, a task is considered a STEAM activity when it combines two or more of these two STEAM subjects of study. This approach strives to prompt curiosity, interest and wonder through exploration, discovery and hands-on learning. It is based on the concept that it is not enough to know about science or maths, or any other subject, but there must be a shift towards actually being able to apply science or maths in a meaningful way. STEAM puts inquiry, creativity and collaboration at the heart of learning.

From STEM to STEAM

The original STEM involved only Science, Technology, Engineering and Maths lacking the more creative side of learning. It was the realization that scientists, engineers and mathematicians could not possibly do their jobs successfully without creativity that promoted the inclusion of the Arts, changing STEM to STEAM. There must be a sprinkle (or much more than a sprinkle!) of creative thinking for experiments, creations and innovation to take place. But it also works the other way around: artists use their STEM knowledge to enhance their artistic productions (be it musicians, painters, sculptors or dancers). The Arts truly complete the package celebrating STEAM's strong holistic view of learning within a well-balanced and integrated curriculum.

STEAM and Language Learning

Doing STEAM in the language classroom does not mean that learners will stop engaging with language learning. On the contrary, scientists, engineers, technologists, artists, and mathematicians all need literacy and communication skills. STEAM experiences shouldn't be something separate from what you do already in your lessons – they should be connected. In fact, STEAM and language learning fit very nicely together. It follows a CLIL (Content Language Integrated Learning) approach where students learn language through different subjects.

Any topic, theme or project can easily be linked to a STEAM activity, e.g. designing something and describing it, doing research with technological devices, counting and learning about numbers, science experiments related to the topic you are teaching, and using artistic forms to present information are all easy ways to integrate language with STEAM.

Example of how to apply STEAM

If you are teaching about houses, learners can be asked to design their own houses. To do this, they will have to use a lot of language in the process:

1. Learners learn new language when doing research about different types of houses online (technology).
2. Learners discuss with others in their group what they have found out, e.g. stability, why people build houses, why people build houses with certain materials (science).
3. Learners plan, sketch their design and build a house made of recyclable materials in groups while they use the vocabulary they know, e.g. "wall, door, window..." (engineering).
4. Learners analyse the shapes they've used or count the number of walls and windows (maths).
5. Learners decorate their house to make it attractive and then describe it to the rest of the class (art and design).

Why do we need STEAM?

The 21st century workplace demands life-long learners and individuals who can easily adapt, think ahead and innovate. STEAM activities stimulate the development of essential skills that meet the needs of a changing world. Education is about developing skills that are useful across disciplines and stick with the individual through life.

Skills learnt through STEAM are:

These skills are key to preparing individuals for their future jobs and lives where creativity and innovation are becoming the norm. Although it is impossible to predict what jobs and lives our learners will face when they are adults, we can help them acquire those key skills needed to thrive in an unknown future. Our learners will most probably need to be able to function in a technological and fast-changing environment and they will need to know how to...

- apply knowledge and skills to the real world,
- come up with unique solutions,
- create something new,
- re-design something to improve it,
- overcome challenges,
- explore problems from multiple perspectives,
- direct their own course of action,
- take ownership of tasks,
- communicate ideas,
- work collaboratively with others,
- feel safe taking risks.

STEAM helps develop innovative and forward-thinking mindsets. These skills provide learners with the tools to be able to apply their learning to an array of challenges in their lives. Individuals who can fall back on patterns of thinking in unfamiliar situations are using their well-developed habits of mind to understand the world and solve problems skillfully.

Dissecting STEAM

Science

Science involves thinking, observing, experimenting, making predictions, sharing discoveries, forming questions and exploring how the world works.

It is common to hear that children are born scientists. From a very young age babies' experiences allow them to try to figure out how the world around them works. These explorations reflect the basic steps of the scientific method. Babies perform little experiments with the data they collect to test their own theories about the world (their own little guesses about things).

A baby drops her spoon by accident.

Mum picks up the spoon and gives it back.

Baby drops the spoon again... by accident.

Mum picks up the spoon and gives it back.

Baby drops the spoon again... "by accident"...

In the example of repetitive play above, mum finally realises this is not an accident – this is her baby exploring cause and effect, and the concept of gravity long before she can really understand it. This is what scientists do: they tinker, they experiment, they test, they repeat. Children benefit immensely from adults encouraging them to do more and to expand their potential experiences intentionally.

SIMPLE SCIENCE TOOLS AND MATERIALS:

- magnifying glass
- food coloring
- tweezers
- tongs
- plastic containers
- plastic cups
- measuring cups
- scales
- playdough
- ice
- water
- soap
- sand
- stones
- salt
- soil
- vinegar
- items from nature

Try this

What makes objects sink or float?

STEAM areas: Science (exploring density) and Maths (sorting, identifying size of objects)

Language connections:
Toys/school objects. Sink/float.

- **Prepare:** Fill containers with water (one for each group).
- **Demonstrate:** Use a piece of aluminum foil to clarify the meaning of the words *sink* and *float*: crumple the foil into a ball and watch it sink – flatten it out and watch it float.
- **Predict:** Learners choose five toys and mention what they are made of. They sort them according to whether they think they sink or float.
- **Explore:** Invite learners to place the objects in the water in their containers one at a time, saying their names and materials as they experiment, e.g. plastic boat.
- **Record:** Learners record the results and notice differences and similarities with their predictions.
- **Reflect:** Were your predictions similar or different to the results? Did all the big/small objects sink? Did all the objects of the same material sink/float? Help learners explore the concept of density – rather than size. Show a photograph of the Titanic or a large cruise ship to help understanding of this concept.

Discover more great STEAM activities with English Code at **english.com/englishcode**

Technology

What comes to mind when you think about technology? Computers? Smartphones? Smartboards? Tablets? Apps? These are all high tech tools and gadgets. Activities that are technology based can require the use of sophisticated electronics, but can also include activities that involve simple machines and tools that make jobs easier. Technology has evolved significantly over time and so the latter are now considered low tech tools, but still technology.

ELECTRONIC TECHNOLOGY INCLUDES:

- computers
- tablets
- smartphones
- smartboards
- cameras
- circuits
- electronic scales
- stopwatches

NON-ELECTRONIC TECHNOLOGY INCLUDES:

- scissors
- gears
- wheels
- torches
- funnels
- ramps
- measuring cups
- screwdrivers
- tweezers

As children use these tools, they are mastering their observation and cognitive skills while they learn about cause and effect, and how things work. Children start to identify which tools, simple or complex, can help them accomplish tasks in easier and more successful ways. The use of tools can take place at different stages of a STEAM activity: using a **tablet** to do research in the planning stage, using a **torch** during the process of experimenting and using a **digital camera** for collecting data to present findings later.

Try this

Build a robot with at least one special feature.

STEAM areas: Technology (exploring machine parts, using a tool) and Engineering (building a robot)

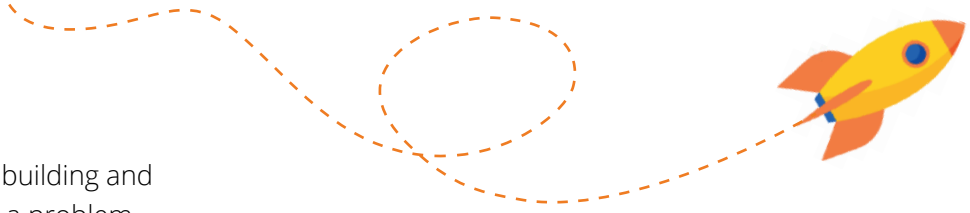
Language connections: Parts of the body. She/He/It has.

- **Prepare:** Collect old appliances that don't work, like old clocks, remote controls, computer keyboards, etc that can be taken apart using a screwdriver. Put recyclable materials and loose parts in bowls/baskets.
- **Demonstrate and predict:** Show how to use a screwdriver by taking something apart yourself. Ask learners what they think is inside the machine. Show the inside parts of the machine (e.g. nuts, bolts, wires). These will be that one special feature the robots must have.
- **Plan:** Learners, in groups, discuss the materials that are available and which will be their special feature. They sketch out their robot.
- **Explore:** Learners use a screwdriver to take apart old appliances and explore the machines' parts. They sort the parts into small bowls to share with the whole class. Groups build their robots out of recyclable materials, loose parts and at least one special machine part.
- **Record:** Learners compare their sketch to the actual robot.
- **Reflect:** Learners present and describe their robots to the rest of the class. Did you know machines had all those parts inside them? Was it easy or hard to use a screwdriver? Did the screwdriver help you take apart the appliances? How would you have done it without a screwdriver? Was your actual robot similar or different to your sketch? Which special feature did you choose? Would you change anything?
- **Re-design:** Provide time in case learners want to re-design anything and reflect again.

Engineering

Engineering refers to the process of building and designing something mostly to solve a problem. It involves using materials, designing, creating, building, testing and maybe having to re-design. Complex physics concepts may be explored, like gravity, balance, force, density and stability, but learning by doing helps these concepts become more accessible.

Children can be seen using engineering habits of mind during play from when they are very young: stacking wooden blocks to build a tall tower or standing cushions up to build the walls of a house.



These are the foundations for more complex understanding of engineering concepts and it is important to facilitate this type of thinking so that it is developed and extended.

ENGINEERING TOOLS AND MATERIALS INCLUDE:

- plastic cups
- magnetic tiles
- craft sticks
- cardboard boxes
- toothpicks
- string
- building blocks
- cardboard tubes
- playdough

Try this

Can you make 3D structures with toothpicks and playdough?

STEAM areas: Engineering (building structures) and Maths (exploring 3D shapes and counting).

Language connections: Shapes and their properties. Counting and writing numbers.

- **Prepare:** Collect objects or pictures of different 3D shapes, e.g. boxes for cubes and rectangular prisms, a tent for a triangular prism, a pyramid for a square-based pyramid, a ball for a sphere, a small drum for a cylinder, an ice-cream cone for a cone, some toothpicks and playdough.
- **Demonstrate:** Show the objects/pictures. Choose one of them and explain that the challenge is to create these 3D shapes with the materials provided. Draw a sketch of one of the shapes on the board using a different colour for each side or a toothpick so that each one can be easily identified. E.g. if you draw a cube, use red for the first "toothpick" you draw, then green for the next, blue for the following and black for the last one to complete the base. Ask learners how many toothpicks they need for that shape. Count them together and talk about the properties of shapes: flat or curved surfaces, edges, and vertices.
- **Plan:** Learners write down the number of toothpicks they think they will need to create each shape.
- **Explore:** Learners build the shapes.
- **Record:** Learners count the number of toothpicks they finally used and write those new numbers (or the same if they were correct) in a different colour next to their predictions.
- **Reflect:** Was it easy or hard to build 3D shapes with these materials? How much playdough did you need to keep the toothpicks in place? (learners will find if they use too little it won't hold the toothpicks in place, but if they use too much, it makes the toothpicks too heavy and they fall down). What would make better materials for this challenge? Were the numbers you predicted similar to those you finally used? Was there any shape that you weren't able to build with toothpicks? Why? (Although it is possible, a sphere can be difficult to build with these materials because of its properties: curved surface, no flat surfaces, no edges, no vertices.)
- **Re-design:** Learners explore building 3D shapes using other materials, e.g. replace toothpicks with straws and craft sticks, replace playdough with gumdrops or jelly beans.

Art and Design

A narrow view of art refers to visual arts alone. It is more useful, though, to interpret it through its broader definition of artistic types: painting, design, drawing, pottery, sculpture, murals, origami, photography, vocal and instrumental music, computer-generated art and music, dance, drama, mime, puppetry, and film.

The Arts perform a very special role due to the creative element they bring to STEAM. Creativity is key during the process of inquiry, experimenting and designing solutions as well as in the communication of ideas and final results. Many concepts that are explored via STEAM can be quite abstract and the use of Art and Design can help them become more tangible.

ART AND DESIGN SUPPLIES:

- drawing paper
- construction paper
- cardboard
- crayons
- markers
- colored pencils
- chalk
- permanent markers
- paint
- pipe cleaners
- watercolours
- feathers
- beads
- ribbon
- bottle tops

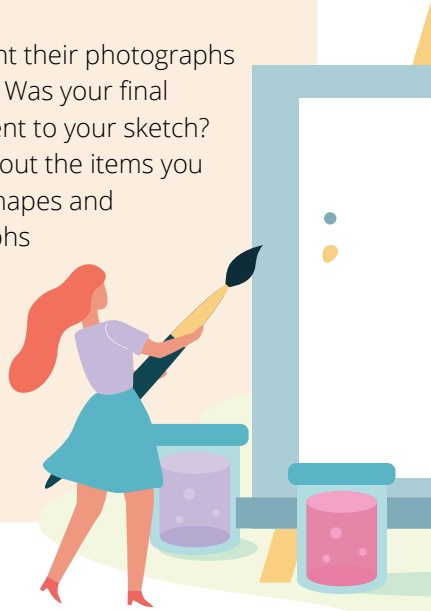
Try this

Make a face out of everyday items.

STEAM areas: Art and Design (using unconventional items to create ephemeral art, taking photographs) and Technology (using digital tools).

Language connections: Parts of the face. Everyday items. It has.

- **Prepare:** Collect everyday items like hair brushes, combs, forks, spoons, scissors, glue sticks, pencils, crayons, markers, erasers, toothbrushes, small plastic bowls, small plastic cups, cups, small balls, coins, paper clips, small toys, rubber bands, hair clips, clothes pegs, and cork.
- **Demonstrate:** Show images of Giuseppe Arcimboldo's art. Ask learners to identify the objects in his paintings: fruit, vegetables, flowers, fish, kitchen utensils and books. Use a digital camera, smartphone or tablet to take a photograph of one of the works of art and explain how you keep the artwork centred and the camera stable. Show what a good photograph and a bad photograph look like.
- **Plan:** Learners, in groups, discuss what objects they will use and sketch the face they plan to create collaboratively considering the shape and size of the objects.
- **Explore:** Learners create their faces. Allow the use of other objects they find around the room.
- **Record:** Learners take a photograph of their face. They then take their face apart and put the items back to create new ones and take photographs of them.
- **Reflect:** Learners present their photographs and describe their faces. Was your final product similar or different to your sketch? Were you able to sketch out the items you used considering their shapes and size? Are your photographs centered? Are they good photographs? Which is your best face? Why? Which is your best photograph? Why?



Maths

Maths refers to the process of understanding patterns, numbers, spatial relationships, size and shapes – another process that begins at a very young age, e.g. exploring the shape of objects with the hands and mouth, or building walls of the same height for a house made of blocks. Children explore these discoveries naturally through play and adults can support this intentionally by maintaining this hands-on and learning-by-doing spirit as children grow older. Thus, abstract concepts in maths become concrete and comprehensible.

MATHS TOOLS:

- cards
- building blocks
- paperclips
- coins
- play money
- counters
- dice
- ruler
- tape measure
- scales
- grid paper
- sorting trays
- hula hoops
- magnetic shapes

Try this

How can you build a strong bridge that holds 20 coins?

STEAM areas: Maths (and counting to 20) and Engineering (building a strong bridge.)

Language connections: Cities. Counting and writing numbers.

- **Prepare:** Collect building materials, e.g. cardboard tubes, boxes, string, pieces of cardboard, craft sticks, paper cups, construction paper, paperclips, masking tape, glue, scissors, etc. Place different items in non see-through bags.
- **Demonstrate:** Research different types of bridges (truss bridge, suspension bridge, and arch bridge). Explain the challenge and show the difference between a strong bridge and a weak bridge. Demonstrate placing and practise counting the coins one by one.
- **Plan:** Learners choose a bag randomly. They reveal the materials in it and sketch their bridges.
- **Create:** Learners build their bridges.
- **Record:** Learners place coins on the bridge one by one and record how many it holds.
- **Reflect:** Is your bridge strong enough to hold 20 coins? How many coins does it hold? How can you make your bridge stronger?
- **Re-design:** Learners re-design their bridge adding new material to make it stronger and test again.
- **Reflect:** What materials made your bridge stronger?

Planning for STEAM

A STEAM lesson should be based on careful planning. The first thing is to think of the question or challenge for learners to explore. These questions or challenges might stem from learners' interests or be part of a topic or project. For it to be labelled as a STEAM activity, it must involve two or more of the disciplines it embraces.

If the activity can be done in groups, then that will encourage STEAM's collaborative spirit. Otherwise, individuals can share their efforts afterwards and reflect on them as a group.

The fact that STEAM activities spring from questions and challenges means there should be a shift in the way errors are treated in the classroom. There is space for trial and error as learners seek their own and unique answers and solutions. Learners should be reassured that if their hypothesis is proven wrong or if their final product looks nothing like their initial plan, there is nothing wrong with it. They might even have the chance of re-designing or testing once more if time allows.

Although learners might not fully comprehend the concepts behind their explorations, it is important to use words that connect to the concept and the process, even with young children. As receptive language precedes productive language, learners might not be able to verbalise using all these concepts and terminology, but using STEAM language will help them enhance their understanding and support the connection with experiences later on.

Observe, investigate, imagine, wonder, plan, predict, sketch, measure...

Weight/height, sink/float, temperature, thermometer...

Smooth/rough, hot/cold, strong/weak, longer/shorter...

Up, down, in, on, under...

STEAM activities are hands-on and require the use of materials: these may be simple or more sophisticated, but it is important for the teacher to collect all the material ahead of time.

The STEAM lesson

The teacher introduces the challenge or question. This is the moment to use appropriate STEAM language for each step and the conceptual terminology that you will explore. Language learners will need their teacher's visual support. Not only telling, but also showing the materials and parts of the process is key in a foreign or second language classroom. Only demonstrate parts of the process so learners do not draw final conclusions at this stage. It is up to the learners to explore, discover and find their own unique solutions or ways of completing the challenge.

Learners, in groups or individually, explore the materials and think about how they can use them to carry out the experiment or solve the problem. With these ideas in mind, learners predict what will happen in an experiment or plan a blueprint of how they will tackle the task.

PREDICT:

- How far do you think the balloon will travel?
- Mark your prediction on grid paper.
- Which object will roll down the ramp?
- Which will slide down it? Sort the objects.

PLAN:

- What materials are you planning on using?
- Draw/Write/Circle the materials.
- Draw a sketch of the boat you will build.

After planning or predicting, give learners time to experiment, build and explore. They need to be reminded that the task is about experimenting, trying, re-trying and perhaps failing, and that that is part of the process.

> *"Failure is success in progress."*
>
> **Albert Einstein**

Learners then record the results by writing, jotting down numbers or drawing. They compare results to predictions and compare final productions to initial sketches to notice differences and similarities.

The last step will normally be the presentation stage where learners present and describe their predictions, sketches, final productions or results. Ask guiding questions to reflect on the process and the activity before evaluating whether to allot a little more time for re-designing or testing again.

- How similar/different was the result/your final production to your prediction/plan?
- What did you like/not like about this STEAM challenge?
- What did you learn?

Setting up space

Due to STEAM's interactive and hands-on nature, these activities involve the use of materials. These can be sophisticated and expensive but not necessarily: it all depends on the activity, the context and budget. STEAM can easily be done without fancy spaces and materials. A STEAM classroom can range from nothing specifically set up to having special areas in the room or in other designated spaces.

- The school might have a science lab with test tubes, magnifying glasses, microscopes or even 3D printing labs and robotics labs with coding, robotics and programming equipment. STEAM can equally be done in the confinements of the classroom, a hallway or the playground.
- Learners might have the chance to work collaboratively and actively explore things, design, build, create and take things apart in a specially designated space called a makerspace. Learners are free to try, fail and try again just like scientists do in their labs. It may include tools for learning coding, programming and robotics, or hammers and saws for engineering, but it may also limit itself to low-tech tools like containers full of craft supplies and recyclables.
- Tinker tubs are a simpler version of a makerspace (a collaborative workspace that contains tools and materials for learners to create and explore with) which can be kept in the form of tubs/baskets/boxes/containers and brought out specially for STEAM activities. Tinker tubs are containers with materials that encourage building, creating, taking apart, planning and designing with or without challenge cards or prompts. Each container might have one type of material or a mix: building blocks, craft sticks, plastic cups, bottle tops, toilet paper rolls, screwdrivers, old clocks and keyboards, keys and padlocks, etc. These containers are set out for learners to tinker with and experiment.
- Investigation stations replace the typical learning centers seen in some classrooms. This involves setting up materials, tools and resources that learners use to investigate, study and test. The teacher's role is to guide explorations in each station with questions and STEAM language. Inviting learners to extend their investigations will prompt overlaps in the process of learning in each of these stations. This is essential to STEAM learning so that the focus is on at least two areas being explored together. E.g. If learners are exploring in the engineering station building a tall tower using toothpicks and playdough, the teacher can extend this investigation by asking learners how they can measure their towers – they will have to find measuring tools in the maths station to do so.

Examples of investigation stations are:

- **Science station:** containers, sand, water, plastic and rubber items that sink or float, natural material, magnifying glass. meat thermometers, egg beaters, mixing bowls, measuring cups, salt, baking soda...
- **Engineering station:** a set of challenge cards, building blocks, toothpicks, playdough, plastic cups, cardboard tubes...
- **Research station:** iPads, books, maps, encyclopaedias, tablets, computers, fiction and non-fiction books...
- **Art and design station:** paint, shaving foam, cardboard, tablet for photography and filming, clay, playdough, scissors, masking tape, glue, costumes...
- **Maths station:** a set of challenge cards, rulers, measuring tape, calculators, items of non-standard units of measurement (paper clips, rubbers, building blocks)...
- **Recording station:** a set of challenge cards, grid paper, pencils, sketch paper and recording sheets...
- If you have nothing specifically set up for STEAM activities, you will only need some containers, baskets, bowls, bags or boxes to present materials activity in an inviting way.

Do you dare?

Of course you do! There is not one way only of doing STEAM.

STEAM comes in many different shapes and sizes: it can be complex or simple; it can be done in a designated space or materials can just be brought out for the occasion; it can be embellished with deep questioning or left to simple discovery; it can be a full-blown project or it can be a one-off challenge; it can involve sophisticated machines or simple tools; it can take a whole lesson or 10 minutes of it. Whatever the budget, soace and materials you have access to, STEAM can be done.

Be innovative to instill innovation. Be creative to stimulate creativity. It only takes a positive mindset and a bit of courage to believe in your own and your learners' capacity to learn.