Taighde Éireann
Research Ireland

Engineers Week

Engineering the Moon

Classroom
Resource Booklet

STEPS
Engineers Week
2 - 8 March 2019

BLACKROCK CASTLE OBSERVATORY
The Space For Science

Ireland esero

Engineering to the Moon
Teacher Background

Through this selection of activities students will investigate the challenges and solutions to visiting or establishing human settlements on the Moon. ESA is working on new missions to the Moon in order to study the environment and to develop technologies, which could one day help setting up a lunar base. Perhaps astronauts will be living on the Moon in the next two decades. Humans have learned a great deal from explorations of the Moon in the past. From initially landing and walking on the Moon in 1969 to the later Apollo and Russian missions' rovers. The lunar surface is rocky and dusty with a huge number of deep craters which we can see from images of the Moon.

Space, outside of our home planet, can be an extremely hostile environment for humans to live. Unlike Earth, the Moon has no atmosphere (it is in a vacuum), this means that there is no air to breathe. In addition, this lack of atmosphere leaves no protection from collisions with even the smallest meteoroids (the dust and rock debris present throughout the Solar System) or from harmful radiation from the Sun. One day on the Moon lasts for 27.3 Earth days; of this there are 14 days of day time, followed by 14 days of night time. The temperature variation between day and night time is extreme. The temperature can be as high as +123o C and as low as -233o C, depending on the location.
Building infrastructure on the Moon would imply taking many materials from Earth, which would be very expensive to transport. Therefore, engineers are investigating new building techniques, such as 3D printing, using local materials like the lunar soil (regolith).

Spacesuits must do many jobs. Most of the time, astronauts wear loose-fitting, comfortable "flight suits" when inside a space craft. But if they venture outside then they need much more protection – from heat, from cold and from radiation as well as the airlessness of space and the possibility of being struck by debris.
The spacesuit that provides this protection is a very complex piece of equipment: almost the equivalent of a one-person spacecraft. It contains its own air supply, which also pressurises the suit against the vacuum of space. The suit must deal with huge changes in temperature, the suit's backpack must include both a system for cooling and a system to keep warm. Beneath the outer suit, an entire inner garment helps insulate the astronaut.

When considering building structures on the Moon, children should investigate the strength of triangles as a basic building unit. Under a heavy load, a square distorts easily – it ends up looking like a parallelogram. If you put a brace diagonally across the square, you create two triangles and a much stronger shape. In fact, the triangle is the only shape that cannot be deformed without changing the length of one of its sides. Because it is not easily deformed, the triangle is an extremely popular building shape.

Curious Minds/ESERO Framework for Inquiry

Theme	Engineering the Moon
Curriculum	**Strand:** Energy and Forces, Materials **Strand Unit:** Heat, Forces, Properties and characteristics of materials, Materials and Change **Curriculum Objectives:** • identify ways of keeping objects and substances warm and cold • explore how the shape of objects can be changed by squashing, pulling and other forces • investigate how forces act on objects • explore how objects may be moved • begin to explore how different materials may be used in the construction of homes suited to their environments / • investigate how materials may be used in construction • become aware of and investigate the suitability of different kinds of clothes for variations in temperature **Skills Development:** Working Scientifically, Designing and Making, Investigating, Questioning, Observing, Planning.

Engage

The Prompt	Wondering	Exploring	Considerations for inclusion
• I wonder what it would be like to live on the Moon? • Apollo video – early Moon buggies (1m 29s) • Moon Village – ESA video (4m 26s) ESA • Teach with the Moon videos: Living on the Moon Radiation on the Moon	• How would I survive? • What kinds of things do we need to bring (e.g. spacesuits, food, water)? • What does a spacesuit have to do? • How do I get around when I am there? • How can we design a vehicle to cross difficult terrain? • Can we make models of space buggies to find out how they work? • Imagine we design a house for the Moon, how should we build it?	• Compare what we know about living on Earth vs living on the Moon / in space ESA Teach with Space Activity Shelters around the World • What do humans need to stay alive on Earth? How could we meet these needs in space? ESERO 20 for Junior Classes ISS Education Kit Space Suit Lesson for appropriate. Senior Classes • Compare different lunar rovers using pictures – Apollo vs Lunokhod. Look at explore what space pictures of the lunar surface. What would a vehicle need to be able to move over the lunar surface? •What materials are available on the Moon to make a shelter? What basic structure is needed to form a shelter? Explore with Amazing Triangles to find Do students out which shapes are stronger to build understand with than others.	How will students with SEN engage with the lessons? Use images or reading where videos are not Take more time to is like with younger students – there is no air, we need air to breathe. 'atmosphere' and how it helps us? ESERO Activity: Investigating the Atmosphere

Investigate: Design and Make a Moon Buggy

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
• How can a space buggy be designed to be stable and travel easily over bumpy ground? • (Teacher or children pose the question/ scenario/present the problem to be investigated).	• Predict by drawing the design of a buggy that students think will be stable / travel easily using the equipment provided. Wheel size and location are likely variables. • Children record predictions and provide reasons for their predictions.	• Travelling Space Buggy Activity In groups the children design, plan and conduct inquiry • Make the buggy as designed. Test for stability / ease of travel. Re-design as needed	• Children interpret and discuss their results • Present their findings: How are the buggies the same? different? What makes the best buggy? • Propose explanations and solutions based on the data.

Investigate: Engineering a Moon Shelter

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
• How do you design a shelter to protect from the hazardous environment of the Moon?	• Draw your ideal Moon shelter and label the most important features. • Describe the protection your shelter provides and list the materials you would need.	• Conduct an activity depending on what the students have decided to create – this may include various geodome design options (see Making Connections).	• Children interpret and discuss their designs and ideas. • Present their findings: Present to the class the reasons for choosing the particular design features.

Take the Next Step

Applying Learning	Making Connections	Thoughtful Actions

• Build a Dome: Make a geodome from paper straws
• Scale up your dome: team build a larger dome: the mega-engineering challenge! Support video here.

For junior classes: A Journey into Space

How much would you weigh on the Moon? (Maths Extension)

• How often do we see triangles in nature/built environment? Carry out a shape scavenger hunt.
• Mission-X – Train Like and Astronaut: An international educational challenge from the European Space Agency focusing on fitness and nutrition that encourages students to train like an Astronaut.

Reflection	• Did I meet my learning objectives? • What went well, what would I change? • Were the cross-curriculum opportunities used? • Are the children progressing with their science skills? • Have I recorded and reviewed any new vocabulary? • What questions worked very well? • What questions didn't work well? • Ask the children would they change anything or do anything differently? • Are there students showing an interest in Engineering or Space Science? • Did I enjoy teaching through this theme?

Activity Links

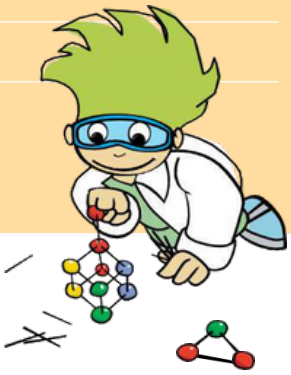
Video: Moon Buggies https://www.youtube.com/watch?v=5cKpzp358F4
Video: ESA Moon Village https://www.esa.int/spaceinvideos/Videos/2016/03/Moon_Village2
Video: ESA Living on the Moon
https://www.esa.int/Education/Teach_with_the_Moon/Making_a_Home_on_the_Moon
ISS Education Kit Chapter 2: Travelling to Space PDF
https://www.esa.int/Our_Activities/Human_and_Robotic_Exploration/Education/Primary_level_ISS_Education_Kit_-_download
Design a Real Spacesuit https://esero.ie/wp-content/uploads/2015/01/20_A-real-spacesuit.pdf
Amazing Triangles DPSM Activity https://www.sfi.ie/site-files/primary-science/media/pdfs/col/triangles.pdf
Investigating the Atmosphere DPSM Activity https://esero.ie/wp-content/uploads/2015/03/Investigating-The-Atmosphere-Activity-2.pdf

Travelling Space Buggy Activity https://esero.ie/wp-content/uploads/2015/01/40_The-travelling-space-buggy.pdf
Shelters Around the World ESA Activity http://esamultimedia.esa.int/docs/edu/PR37_Moon_shelter.pdf

GeoDome from Straws https://learning-resources.sciencemuseum.org.uk/wp-content/uploads/2017/08/Build-A-Dome.pdf
Large Newspaper Geodome https://spaceplace.nasa.gov/moon-habitat/en/
Video of newspaper geodome https://www.youtube.com/watch?v=B4EJ_jkrNuc
A Journey into Space (Junior Classes) https://esero.ie/wp-content/uploads/2015/01/18_A-journey-into-space.pdf
How much would you weigh on the Moon? https://esero.ie/wp-content/uploads/2015/01/68_How-much-would-you-weigh-on-other-celestial-bodies.pdf
Mission X: Train Like an Astronaut https://www.stem.org.uk/missionx

Activity
Amazing Triangles

Equipment	Box of cocktail sticks, Bag of marshmallows, mini-marshmallows or any soft sweets.
Preparation	None.
Background information	The triangle is a strong shape and is used to support structures. Under a heavy load, a square distorts easily – it ends up looking like a parallelogram. If you put a brace diagonally across the square, you create two triangles and a much stronger shape. In fact, the triangle is the only shape that cannot be deformed without changing the length of one of its sides. Because it is not easily deformed, the triangle is an extremely popular building shape.
Prompt questions	What shapes do you know? Can you pick out any shapes in this room? If you look at a bicycle (or a picture of one) can you pick out any shapes? What shapes help the bicycle move? (Circles, wheels) What shapes make the bicycle strong? (Triangles in the frame). How would you make a corner stronger on a bench or a table? (Add a strut across the corners to make a triangle.) Forces, Materials and their properties.
Content Strands	Experimenting, Designing and making, Investigating, Observing, Analysing.
Skills	

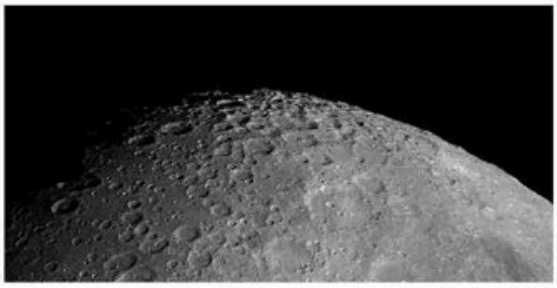


curious minds
Discover STEM

→ Activity 3: Could you live on the Moon?

Do you think the environment on Earth can be extreme? Well, space is much worse!

Study the following pictures. Can you identify differences between the Moon and the Earth? Which hazards would astronauts come up against on the Moon? Write your answers and describe some of the Moon's characteristics in the lines below.



The Moon is...

→ Activity 4: My Moon shelter

How would you design a shelter to protect astronauts from the hazardous Moon environment?

1. Draw your ideal Moon shelter and label the most important features. Describe the protection your shelter provides and list the materials you would need.

materials	it protecs from...

My Moon shelter...

Space exploration is extremely difficult.

- The environment is very harsh.
- The distances are very big, even if the destination is the Moon.
- Travelling to space is very expensive. Depending on the final destination, the cost per kilogram can vary from a few thousands of euros to several hundreds of thousands of euros.

2. Would you like to update your initial design? Would you still use the same materials?

3. Build your own Moon shelter!

A real spacesuit
Space technology

20

time
50 minutes.

learning outcomes
To:
- know that clothing protects against heat loss in the cold
- know that during a space walk, an astronaut needs to take an air supply, just like a diver

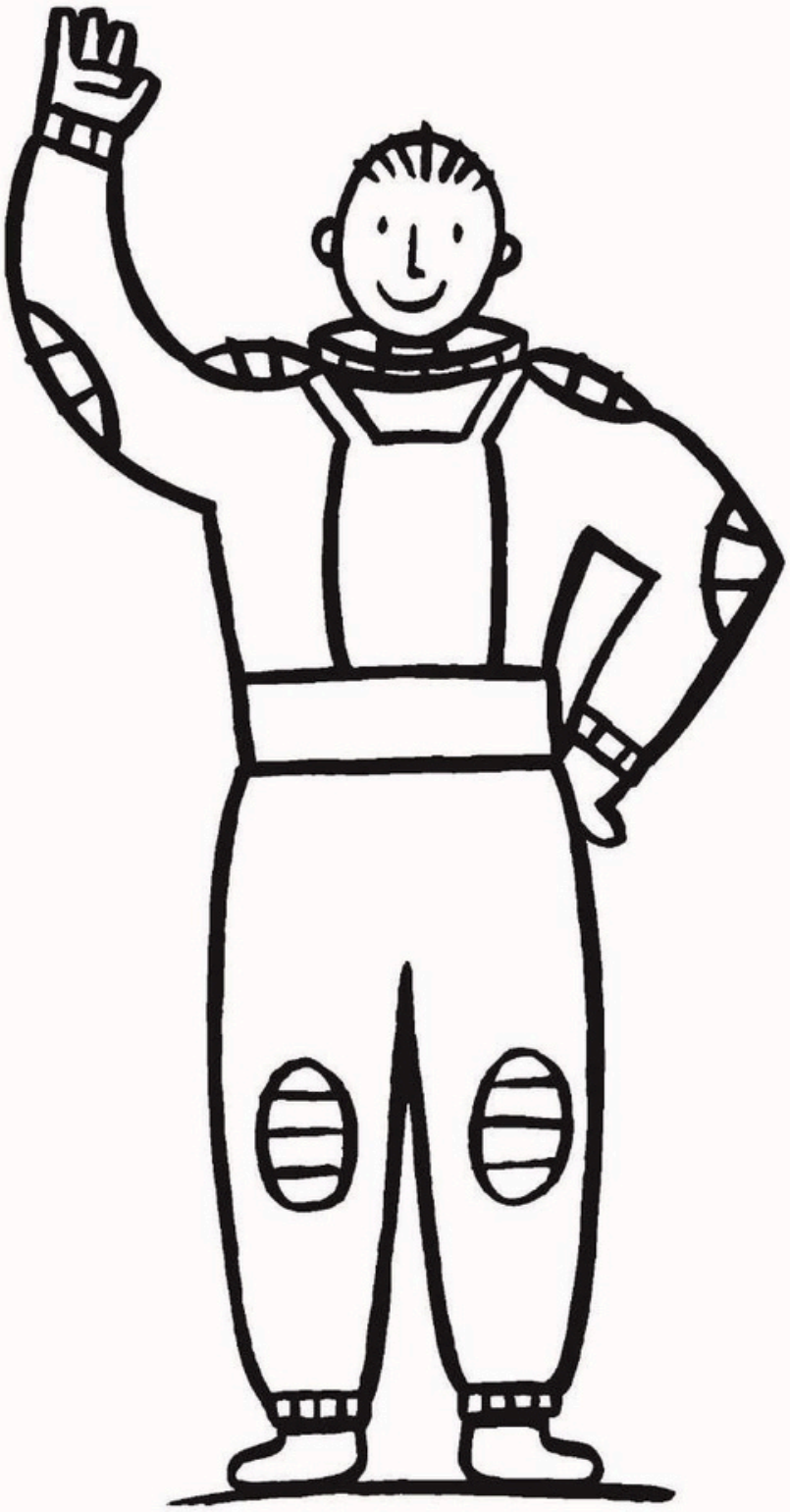
end product
- an astronaut with a spacesuit designed and crafted by the child

materials needed
- photograph of astronaut in space (Appendix)
- photograph of diver (Appendix)
- 12 toilet paper rolls, cut in half
- cotton wool
- coloured card
- glue
- paint
- scissors
- colouring pencils

Preparation
For the activity **In the rain and in the sun** you will need the photographs of the astronaut in space and the diver from the Appendix.
For the activity **Make a spacesuit** make 24 copies of the worksheet on card.

In the rain and in the sun 10 min.
Sit in a circle with the children. Ask the children what sort of weather it was when they came to school this morning. What clothes were they wearing? Was it raining? What do you wear when it rains? Why do you wear a raincoat? Explain that a raincoat keeps your clothes dry. It keeps the water out. Do the children know something that keeps them warm? Come to the conclusion together that you wear warm, thick clothing when it is cold outside. Explain that you can change your clothing according to the weather. Show the photograph of the diver. Explain that a diver has to take air with him to be able to breathe underwater. People in space cannot breathe like they do here on Earth. That's why astronauts have to take their own air supply with them. It can also be very cold in space. That's why the astronauts wear special suits. Show the photograph of the astronaut.

Explain to the children that they are going to make a spacesuit that will keep the astronaut warm and have its own air supply.



40

The travelling space buggy

Space technology

Time

60 minutes

Learning outcomes

To:

- find out what is needed for a vehicle to travel along
- know what specifications a space buggy must meet to be able to travel on a bumpy surface

End Product

- A space buggy

Materials Needed

- photograph of Mars Lander (Appendix)
- 12 1-litre drink cartons
- 12 containers
- coloured card
- wooden skewers
- scissors
- glue
- paint
- toilet paper rolls
- large and small buttons
- container with sand and stones

Preparation

For the activity **Move it** you will need a block trolley and a doll's pram or buggy. You will need the photograph of the Mars Lander from the Appendix. For the activity **Your space buggy** you will need 12 containers with scissors, glue, paint, toilet roll tubes, large and small buttons, wooden skewers, coloured card, and a milk carton. You will also need a large container with sand and stones for the children to test their space buggies in.

Move it 30 min.

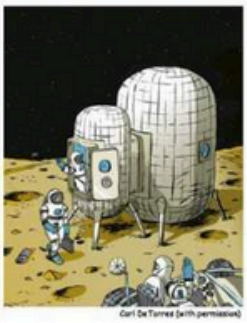
Take the children outside. Show the block trolley and the doll's pram or buggy. Where will the trolley and the pram or buggy be able to move best, on the playground or in the sandpit? Encourage several children to have a go moving the trolley and the pram or buggy. Now take a few blocks out of the trolley and put them on the ground. Ask the children to try pushing the doll's pram or buggy and block trolley over the blocks on the ground. Is this easy or difficult?

The children make a space buggy that can move across a bumpy surface, like the sandpit and over the blocks in the playground.

National Aeronautics and Space Administration

Build a Moon Habitat!

You can be a Moon explorer too. Practice by building your own Moon habitat. Pretend you are an astronaut working with your teammates on the Moon to build your new home.



What you need:

- 148 sheets of newspaper (use a paper with large pages—tabloid size is too small—and use the full square spread)
- Pencil
- Masking or packaging tape
- Scissors
- Yardstick
- Stapler (heavy-duty, if available)
- Bed sheet, colored tissue paper, or more newspapers for "walls" (optional)
- White glue or glue stick (optional)

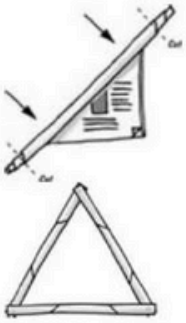
What to do:

1. *Use four sheets of newspaper to build each log. Lay the sheets out flat, one on top of the other.*

2. *Set the pencil in the corner and roll across on the diagonal. Use the pencil to help you get started, and then remove the pencil. Roll evenly, but don't try to make the logs as thin as the pencil. When you get to the opposite corner of the paper, you'll have a tube or log. Tape the log shut.*

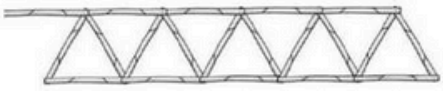
   Repeat this process until you have 37 logs. Then trim the ends a bit, making sure all the logs are the same length. They will be around 30 inches long.

   Now you will need a big, open space in which to construct the habitat.



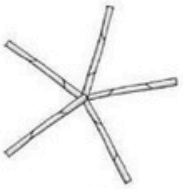
3. *Staple three logs together to create a triangle. Repeat until you have five triangles.*

4. *Staple the five triangles to each other at their bottom corners. Add connecting logs across the top.*



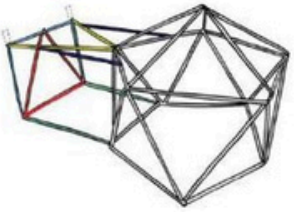
Find this activity online and learn more by visiting NASA's Space Place website: http://spaceplace.nasa.gov/moon-habitat.
Find more fun activities at http://spaceplace.nasa.gov/menu/do.

5. Staple the remaining five logs together at the center to make a star.



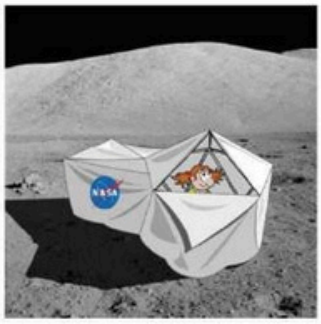
6. Then raise the five connected triangles, or walls, off the floor and staple the ends together to form a five-sided (pentagonal) structure. It helps to have one person hold up the walls while another person staples.
7. Now staple the free ends of the star to the junctions of the triangles on the top of the base, and the structure will stand by itself.

Construct the "airlock:"



8. You should have 12 logs left. These will make the "airlock." Staple three logs together to make another triangle (red in above drawing). Use two more logs (green) to attach the base of this triangle to one of the base logs of the "habitat." This triangle becomes the airlock door.
9. Using three more logs (blue), create a square by stapling them around the "door." The side logs will be a bit too long, so cut them off to make a square.
10. Use two more logs (yellow) to make a triangle to support the airlock at the top. To do this, staple the ends to the two top corners of the square and staple the other ends together where the triangles meet on the habitat.
11. Use the last two logs (purple) to stabilize the airlock as shown in the drawing.

Fill in with solid walls (optional):



12. You can give the structure "solid" walls by either carefully draping a sheet or two over it or by covering each section with tissue paper or newspaper. To do this, smear glue onto the logs and gently press pieces of colored tissue paper or newspaper onto the triangles. Don't forget to leave a door! You can rip or cut off the loose edges of the tissue paper.

Don't forget the NASA logo! Print it, cut it out, and pin or glue it to the outside of your Moon habitat. (http://spaceplace.nasa.gov/review/moon-habitat/nasalogo_color.pdf)

Find this activity online and learn more by visiting NASA's Space Place website: http://spaceplace.nasa.gov/moon-habitat. Find more fun activities at http://spaceplace.nasa.gov/menu/do.

Engineering the Moon:

Some Cross-Curricular Ideas*

ENGLISH

(and Arts) – How do I become a Space Traveller? ESERO activity combining literacy, creativity and drama to imagine what it would be like to travel in space as an astronaut. www.esero.ie/wp-content/uploads/2015/01/78_How-do-you-become-a-space-traveller.pdf

MATHS

How much would you weigh on the Moon? For older classes, looks at the distinction between mass and weight.
https://esero.ie/wp-content/uploads/2015/01/68_How-much-would-you-weigh-on-other-celestial-bodies.pdf

PE

Zero gravity training / high intensity training
Mission X Train Like an Astronaut http://trainlikeanastronaut.org/

SESE

Space Picnic: DPSM inquiry-based learning, what would food taste like in space?
https://esero.ie/wp-content/uploads/2017/04/Space-Picnic-2016-ENGLISH.pdf
Shelters all around the world : Comprehensive handouts and activity looking at how people live in different climates and cultures.
Engineering activities available at Engineers Week Website
http://www.engineersweek.ie/engineeringactivities/
How much Air? – Science investigation measuring lung capacity – senior classes.
www.epa.ie/pubs/reports/other/education/primary/impactsandpollution/EPA_education_impacts_deep_breath.pdf

ARTS

See *English*
Drama: Act out Moon walking
Deirdre Kelleghan developed the Deadly Moons Activity hosted on AstroEdu, it is available here:
https://astroedu.iau.org/en/activities/1404/deadly-moons/

EXTRA

ICT: Create an animation movie, graphs, news broadcast, internet, comic strip, movies of your journey to the Moon.

Curious Minds/ESERO
Framework for Inquiry - Promoting Inclusion

SPECIAL EDUCATION SUPPORT SERVICE
building on ability

When planning science activities for students with Special Educational Needs (SEN), a number of issues need to be considered. Careful planning for inclusion using the framework for inquiry should aim to engage students in science with real purpose. Potential areas of difficulty are identified below along with suggested strategies. This list is not exhaustive, further strategies are available in the Guidelines for Teachers of Students with General Learning Disabilities (NCCA, 2007).

ENGAGE

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Delayed language development/poor vocabulary/concepts	• Teach the language of science demonstrating meaning and/or using visual aids (material, property, strong, weak, textured, dimpled, absorbent, force, gravity). • Have the student demonstrate scientific phenomena, for example gravity —using 'give me, show me, make me,' as much as possible. • Assist the student in expressing ideas through scaffolding, verbalising a demonstration, modelling. • Use outdoor play to develop concepts.

INVESTIGATE

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Fear of failure/poor self-esteem/fear of taking risks	• Model the speculation of a range of answers/ideas. • Repeat and record suggestions from the students and refer back to them.
Understanding Time and Chronology	• Practice recording the passing of time, establish classroom routines that draw the students' attention to the measurement of time. • Teach and practice the language of time.
Fine/Gross Motor Difficulties	• Allow time to practice handling new equipment. • Allow additional time for drawing diagrams, making models etc. • Give students the option to explain work orally or in another format.
Short Term Memory	• Provide the student with visual clues/symbols which can be used to remind him/her of various stages of the investigation.

TAKE THE NEXT STEP

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Developing Ideas	• Keep ideas as simple as possible, use visuals as a reminder of earlier ideas. • Discuss ideas with the whole group. • Repeat and record suggestions from students and refer back to them. • Encourage work in small group and in pairs.
Communicating Ideas	• Ask students to describe observations verbally or nonverbally using an increasing vocabulary. • Display findings from investigations; sing, do drawings or take pictures. • Use ICT: simple written or word-processed accounts taking photographs, making video recordings of an investigation.

REFLECTION

- Did I take into account the individual learning needs of my students with SEN? What differentiation strategies worked well?
- Did I ensure that the lesson content was clear and that the materials used were appropriate?
- Was I aware of the pace at which students worked and the physical effort required?
- Are there cross curriculum opportunities here?
- Are the students moving on with their skills? Did the students enjoy the activity?

More strategies, resources and support available at **www.sess.ie**

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