SPACE WEEK

Our Planet · Our Space · Our Time

Resource Book for Teachers
TOPIC: Magnetic Sun & Space Weather

Our Planet · Our Space · Our Time

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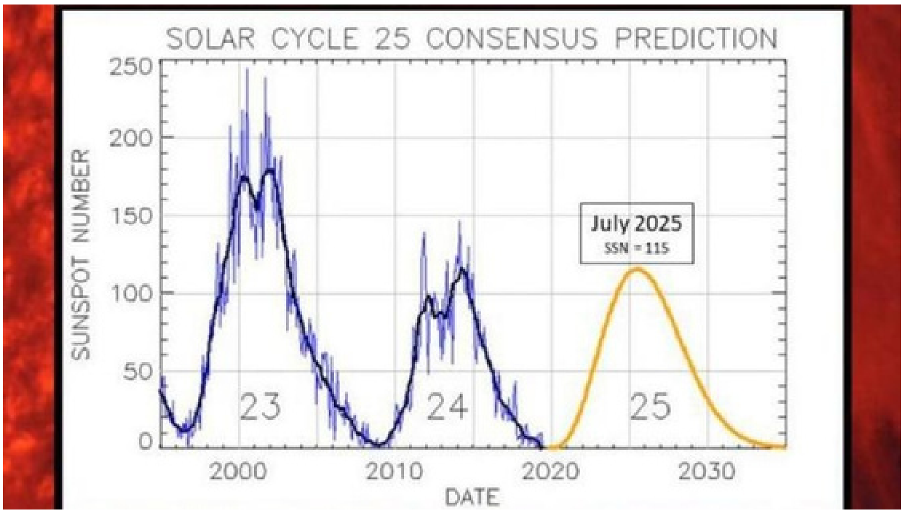
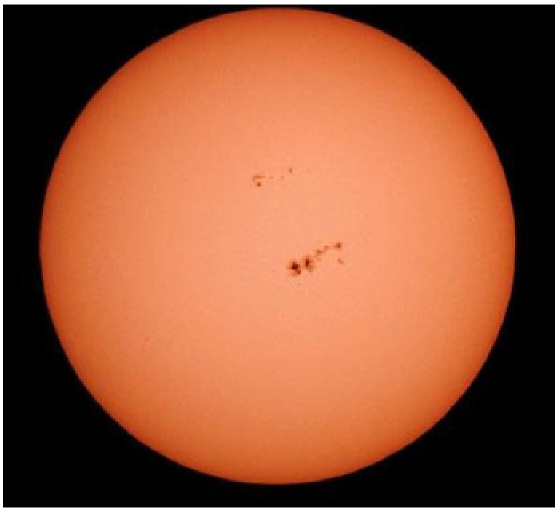
Space Weather

Just like we experience weather on Earth, there's weather in space! The Sun may look very constant and quiet from Earth, but it's constantly spewing out a stream of particles called the solar wind. Space weather is activity on the Sun that can affect Earth and interact with our technology.



Changes in the activity of the Sun occur in eleven-year cycles and the Sun itself rotates every 27 days. We are currently near the beginning of Solar Cycle 25, predicted to peak in 2025. During solar maximum the Sun is more active, there are more sunspots and a greater chance of bad space weather. Sunspots can be seen on the surface of the Sun as darker regions, because they are slightly cooler than the rest of the Sun's surface. Sunspots can appear and disappear over days or weeks.

The Sun produces heat, light and energy all the time. As charged particles move inside the Sun they produce strong magnetic fields. Students can explore the magnetic effects of moving charges by making their own electromagnets.



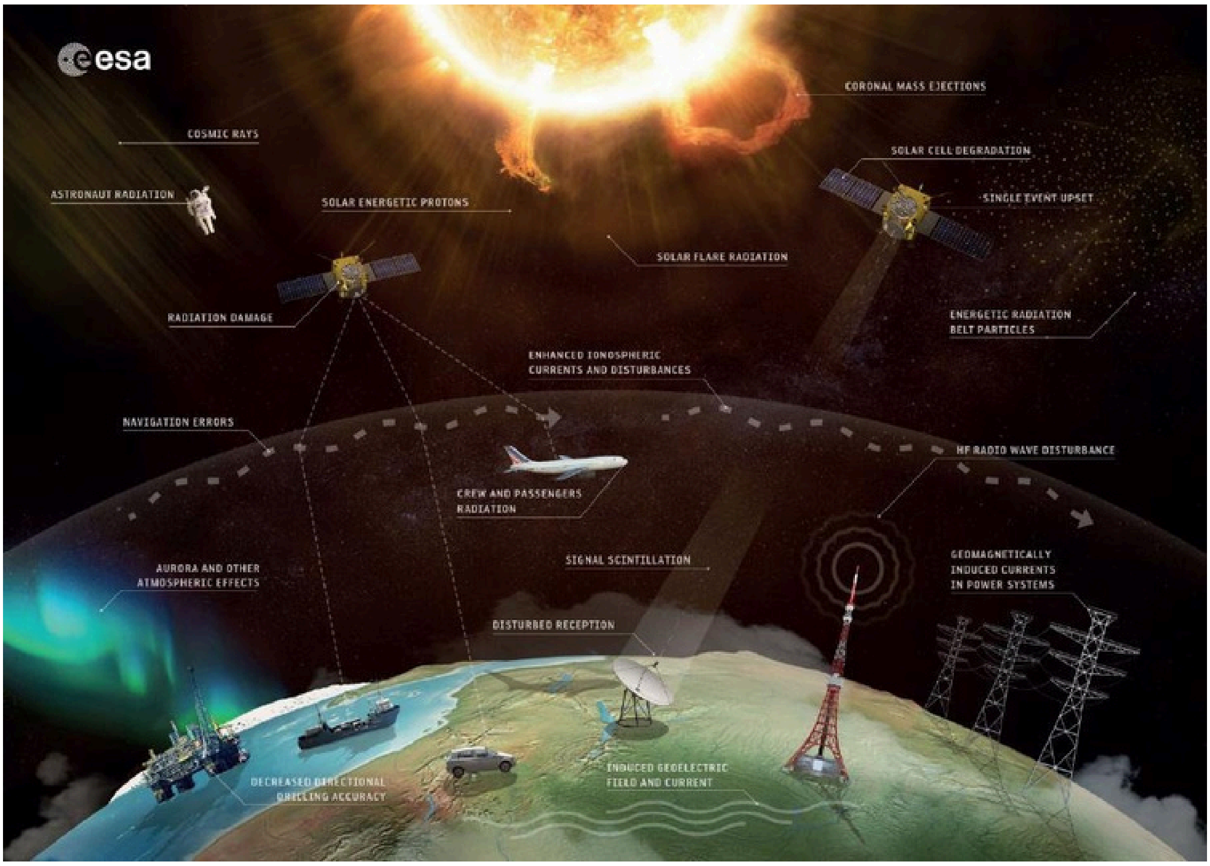
Flares and large ejections of mass (coronal mass ejections or CMEs) occur over timespans of minutes to hours. The energy of the Sun constantly blows out a 'solar wind' of electrified particles. When charged particles leave the Sun (as solar wind, or as CMEs) they carry part of the Sun's magnetic field with them. Earth is surrounded by a magnetic field (our magnetosphere) that protects us from the worst effects of solar storms. However, solar storms can cause fluctuations in the magnetosphere called geomagnetic storms. Geomagnetic storms have disabled satellites and burned out transformers. This shuts down power grids. These storms can endanger astronauts and make more intense auroras that can be seen from more of the Earth.

Solar flares and CMEs are both solar events. They are not the same thing but can sometimes happen together. Most solar flares and CMEs start in sunspots or groups of sunspots. Active regions are areas of the Sun's surface that typically contain strong magnetic fields and sunspots.

We can observe the Sun directly via special solar telescopes, or by projecting an image with a normal telescope. Students can make an "Earth Speedometer" with a simple magnifying glass to observe the Sun. They will see how fast the Earth rotates by measuring how fast the image of the Sun moves.

Students can explore how the magnetic regions of the Sun are linked to sunspots by viewing current real data of the Sun. The possible effects of space weather can be measured by creating a magnetometer that reacts to changes in the Earth's magnetic field. Students can compare their magnetometer readings to 'official' magnetometer readings shared on https://www.magie.ie/. Aurora are linked to space weather events, so students can view webcams from aurora sites.

Students might want to consider what could happen in the event of another major space weather storm. In 1859, the Carrington Event was the biggest solar storm every recorded. It caused fires in telegraph equipment and aurora were seen as far south as Cuba. If a similar strength event took place today, it could damage power grids and possibly destroy transformers. How would we cope without power for a week? Or a month?



Theme	The Magnetic Sun and Space Weather
Curriculum	Strand > Strand Unit > Curriculum Objectives: Science > Energy & Forces > Magnetism and Electricity • use magnets of different shapes and sizes in purposeful play to explore their effects on different materials • investigate that magnets attract magnetic materials, such as iron and steel • investigate that magnets attract certain materials through other materials • explore the relationship between magnets and compasses • explore how magnets have poles and investigate how these poles attract and repel each other • investigate how magnets may be made *passing electricity through a coil around a piece of iron or steel (electromagnet)* • identify some household appliances that use electricity Science > Energy and Forces > Light • be aware of the dangers of looking directly at the sun • explore how objects may be magnified using simple lens or magnifier Science > Environmental Awareness and Care > Science and the environment • begin to explore and appreciate the application of science and technology in familiar contexts Skills Development: Questioning, Observing, Predicting, Investigating & Experimenting, Measuring, Analysing; Designing and Making

Engage

The Trigger	Wondering	Exploring	Considerations
Magnetogram and other images of the Sun from Helioviewer.org or SolarMonitor.org or from Solar Orbiter (https://sci.esa.int/web/solar-orbiter/-/the-sun-and-its-magnetic-properties)	How big and how far away is the Sun? Review material from the Solar System resource. How long does it take for light to reach us from the Sun? How does the Sun affect us on Earth? What is space weather?	Explore magnetism in the classroom by giving children a small plotting compass and asking them to see does the compass needle always point in the same direction? If not, could there be anything magnetic or with electricity that might be affecting it? To prepare to make the Earth Speedometer, have a selection of magnifying glasses that the children can look through.	

Investigate: Magnetism

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
Where is the strongest magnetic region around a bar magnet? Older children might make up their own questions about magnetic fields and magnetic strength.	Children should refer to their previous understanding of magnets to predict that the poles are where the magnetic field is strongest. Children might predict that magnetic effects are strongest near the magnet and weaker further away.	Children might use iron filing “pictures” or small plotting compasses to explore the magnetic regions around a bar magnet. Children might use paper clips to test the strength of the magnets. Do not use iron filings sprinkled directly on the magnets, they are very hard to remove.	Children may share their results in diagrams or charts depending on which question they have investigated.

Curious Minds/ESERO Framework for Inquiry

Design & Make: Electromagnets (5th/6th classes)

Explore	Plan	Make	Evaluate
How can we make an electromagnet? See this video on YouTube.	Use a large iron nail or bolt, 60 cm or more of coated wire with the ends stripped bare, a 1.5 V battery, a tea towel or cloth in case the battery or wires get hot, small magnetic metal items (paper clips).	Follow the video instructions to make your own electromagnet. Different groups could try a different number of turns, or different voltage batteries, or different lengths of wire.	How many paper clips did it pick up? What happens if you increase the number of turns in the coil? What happens if you remove the iron core?

Design and Make an Earth Speedometer

Explore	Plan	Make	Evaluate
How can we measure how fast the Earth turns by observing the Sun? Examine and explore different magnifying glasses and lenses.	Where can we set up our Earth Speedometer? What angle is the Sun above the horizon? Where should we set up the paper?	Follow the guide to set up paper at a suitable distance from a lens to view the Sun.	Could the Sun be seen easily? Were there any sunspots? What was the speed of the Earth?

Investigate: Magnetic Sun & Sunspots

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
Are sunspots found in magnetically active regions of the Sun?	This is an observing task as scientists are still trying to work out how sunspots and magnetic regions are related. Children should predict what we would see if the starter question were true. "If sunspots are found in magnetically active regions, what would you expect to see on images of the Sun?"	Observe real data of the Sun each day. View the HMI magnetogram and compare it to the visible light (continuum) image. Are there the same number of sunspots each day? How do they compare to the magnetogram areas? Observations may be taken for a short period of time each day over an extended period.	Students may produce videos that show the changing appearance of the Sun, or record by drawing on a blank circular template. Results may be shared through diagrams, tally tables or charts.

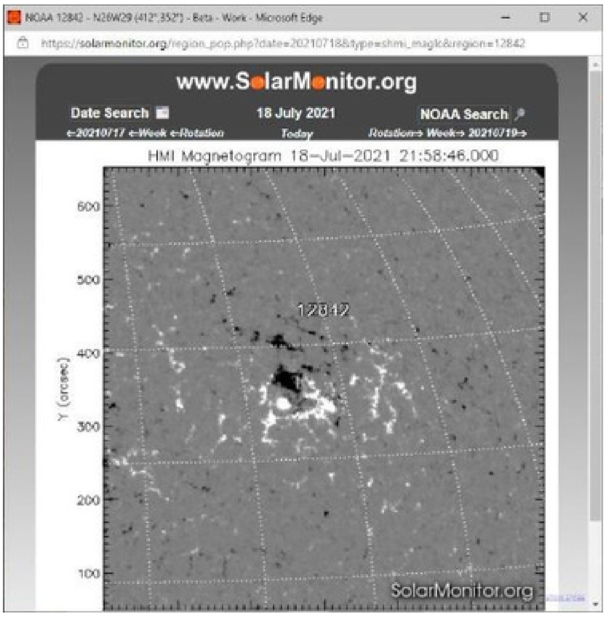
Design and Make a Magnetometer

Explore	Plan	Make	Evaluate
How can we design and make a magnetometer to see changes in the Earth's magnetic field? See design here.	The magnetometer must be able to move freely. It will move a few degrees when the Earth is affected by a geomagnetic storm. How can this small change be more easily seen?	Children may start with the initial design as given and make modifications considering their experience with materials.	When does the magnetometer move? How can it be stabilised? Does it move when there are geomagnetic storms?

Taighde Éireann
Research Ireland

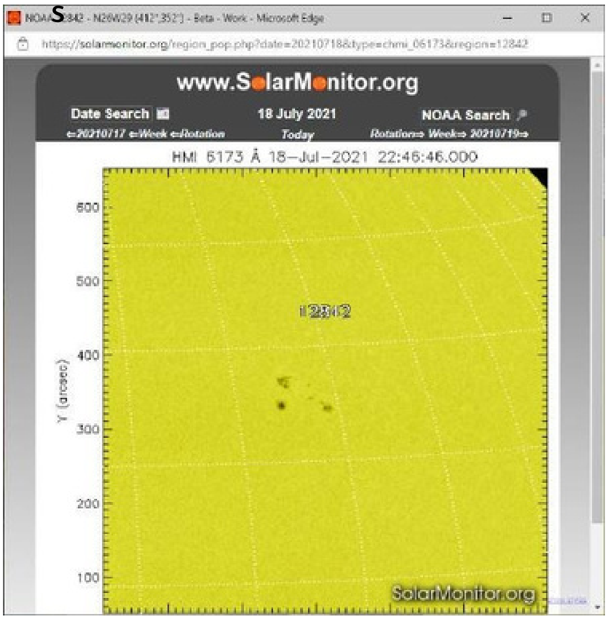
Take The Next Step			
Applying Learning	Making Connections	Thoughtful Actions	
How did people in the past live without electricity? (History > Life, Society, Work and Culture in the Past) What devices do you use every day that use electricity? How would you manage without electricity for a week? During geomagnetic storms aurora might be seen. This site lists webcams that can show aurora: https://seetheaurora.com/webcams. Choose a northern hemisphere site during northern winter, a southern hemisphere site during northern summer. Create aurora (https://americanart.si.edu/artwork/aurora-borealis-4806) or solar corona art. Use black paper, a cardboard template (round for the Sun, wavy for the aurora) and paint, pastels or chalk. **Magnetic Sun & Sunspots**: What other images of the Sun can we view? How do features we see on those images relate to what we have already seen?			
Reflection	Did I meet my learning objectives? What went well, what would I change? Are the children moving on with their science skills? What questions worked very well? What questions didn't work well? Ask the children would they change anything or do anything differently. Are there cross curriculum opportunities here? What further questions did students have?		

The Magnetic Sun & Sunspots



Magnets have poles, called north and south, and those poles can attract or repel each other. The Earth is like a giant bar magnet, with a north magnetic pole and a south magnetic pole. The Sun has a complicated magnetic field, with many north and south poles. On magnetogram images of the Sun these poles are shown as different colours.

Where there is strong magnetic activity, the surface of the Sun is often a little bit cooler, which makes it look darker. These areas can be seen as sunspots. The international sunspot number is worked out by counting the number of sunspot groups (if a group of sunspots all fall within the same 10 degrees of longitude and are at about the same latitude, they are considered part of the same group; a single spot by itself is also counted as a group) and the number of individual sunspots. The sunspot number = No of Groups * 10 + No of individual sunspots. If there is one single sunspot on the Sun, the sunspot number will be 11. Different people might count a different number of sunspots, particularly when they are using different telescopes or looking at slightly different times, so the overall value is found by averaging different observers. This means the sunspot number can sometimes be between 0 and 11.



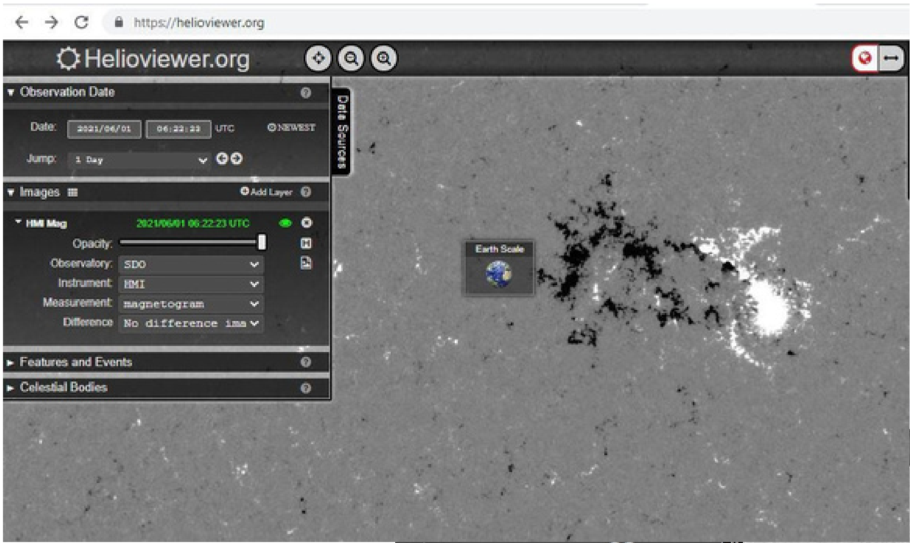
Instruments aboard spacecraft, including the ESA NASA SOHO mission and ESA's Solar Orbiter look at the Sun at different wavelengths. Each wavelength was chosen to highlight a particular feature of the Sun (see SDO Solar Mission for more detail). Scientists study the Sun and try to work out how the different features that they see are connected. Some observatories on Earth still draw the Sun every day, this allows us to compare our current records to records from the past. See SILSO for the lastest picture from the Royal Observatory in Belgium, and see also: Time Lapse.

If you have a specialised solar telescope you can observe the Sun directly. NEVER point a normal telescope at the Sun to observe sunspots. You can use projection methods, if you reduce the aperture of the telescope to avoid overheating. You can find pictures of the

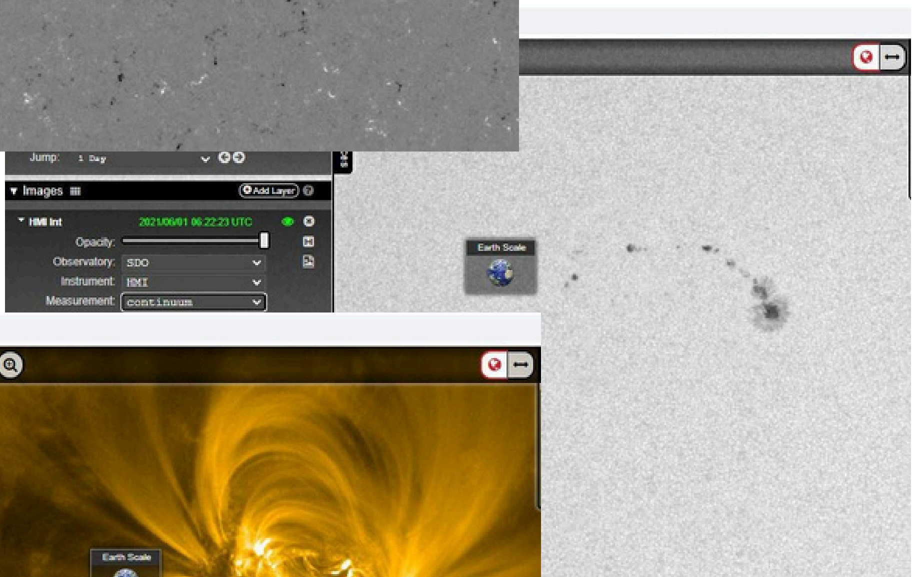
Sun at SolarMonitor.org or Helioviewer.org (or the slightly simplified https://student.helioviewer.org/) or https://helioviewer.ias.u-psud.fr/#

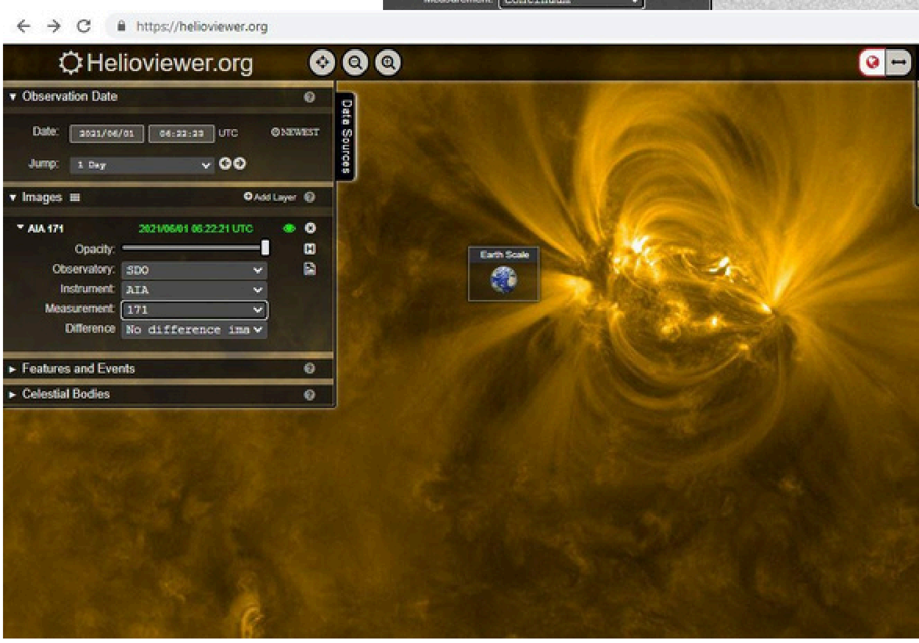
Observing Activity: Look at the continuum picture of the Sun, can you see any sunspots? Look at the magnetogram picture of the Sun, can you see any areas of black and white that are near each other? Compare the size of these features to the size of the Earth. See the DPSM ESERO Framework of Inquiry for a possible investigation activity.

Take the Next Step: Look at other images, which show what the Sun looks like in different wavelengths. Is there a link between what you have seen and other features on the Sun?



These images were all taken on June 1, 2021. The sunspot group below, matches the magnetogram and the AIA 171 view. AIA 171 shows a false colour (gold) image of loops in the corona of the Sun.





Does the shape of the loops remind you of the shape of the magnetic field around a bar magnet?

Earth Speedometer

Equipment:

- Magnifying glass or lens with one convex side (long-sighted eyeglasses will work fine). Choose a lens that's gently rounded. Try looking through several and choose the one that puts the most distance between it and an object seen in focus through it.
- Masking tape
- A chair or stool and some books or boxes
- White paper
- A pencil
- A watch or clock with a second hand

Suggested Class Level: 5th - 6th

Preparation: Find a place where sunlight casts clear shadows on the ground. It can be indoors or outdoors.

Background Information: The Earth turns all the time, that's what makes the Sun appear to move across the sky.

Trigger Question: Is it safe to look directly at the Sun? (NO!) How can we see the Sun if we can't look directly at it? Have you ever used a magnifying glass to focus sunlight?

Activity: Tape the handle of the magnifying glass to the seat of the chair so that the lens extends over the edge and place it in sunlight. Put the paper where the light passing through the lens shines on the ground. Raise the paper closer to the lens or you may need to raise the magnifying glass higher (set it on a stack of books on top of the chair, taping the magnifying glass to the top book instead of the chair) until you get a sharp circle of light, then use books or boxes to prop up the paper or the chair (caution - a sharp focus of the sunlight will set fire to the paper, tape the paper in place so wind cannot move it).

If you do this in winter, when the Sun is low in the sky, tilt the magnifying glass and prop the paper up at an angle to get a clear circle of light.

Draw a tight circle around the spot of light (which is an image of the Sun itself), then use your watch to time how long it takes for the light to completely leave the circle. Does the time for the light to move out of the circle change at different times of day? At different times of year?

Safety: Do not focus the sunlight to a tiny point - it will start burning through the surface (paper, cardboard, plastic, skin)......and NEVER look through the magnifying glass at the Sun.

Take the Next Step:

Try different lenses to produce larger images of the Sun. This makes a simple solar telescope.

Look for dark spots on the image of the Sun - these are sunspots.

Calculation for older students: When the light moves completely out of the circle you have drawn, the Earth has travelled ½° of its 360° rotation. Take the number of seconds it took for the light on the paper to move out of the circle, and multiply it by 720. Work out the length of the day in hours by dividing that number by 3600.

Make a sundial, see the Space Week Resource booklet: The Sun & Shadows

Make a Magnetometer

EQUIPMENT
empty 1.5 to 2 litre drinks bottle
fishing line or string
straw
bar magnet
tape
lightweight card
sequin or small mirror
sand

bright light or laser pointer

ruler (mounted on a wall, about 1m away from the bottle)
scissors

The magnet must hang freely inside the drinks bottle. The card attached to the lower edge of the magnet acts to
i) support the mirror and
ii) dampen the motion of the magnet.

The light should be aimed from outside the bottle, to reflect from the mirror. Mark where the light shines on the wall, about 1m away.
If the Earth's magnetic field changes due to a solar storm, the magnet will move very slightly. This will move the mirror and the dot of light on the wall will change position.

Can you test the system by bringing another magnet near the magnetometer? What would you expect to see?

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.

I NVESTIGATE

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 atwww.sess.ie

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