YEAR 5
STEM Project 1

Science Technology Engineering and Mathematics (STEM) Project – Teacher's Guide

PALMS
PRIMARY AUSTRALIAN LITERACY MATHEMATICS AND SCIENCE

Santos & ESWA supporting earth science education

EARTH SCIENCE WESTERN AUSTRALIA

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How To Use This Resource

The PALMS STEM projects are designed to be used either to supplement normal science lessons in the Earth and Space Science area or to be used as stand-alone projects with science classes, STEM clubs or extension classes.

They are organised using the following sequence:

1. The Challenge
2. Find Out More and Get Thinking
3. Ways To Meet The Challenge
4. Could It Be Better?
5. Report Back To Base

The projects are designed to be completed independently by students although teacher supervision, especially when using equipment such as 3D printers, is strongly recommended.

To clarify with students what skills they need to be using when working on STEM projects, an accompanying PowerPoint presentation titled 'What do STEM Skills look like?' has been prepared. This should be discussed with the students before starting the main project. It needs to be reinforced with the students that they are not trying to think of ways to address the scenarios presented but just to identify the skills they would use. The STEM Skills discussed here align with the WA Department of Education definitions found here: https://www.education.wa.edu.au/what-is-stem-

Students will be asked at the end of the project to identify which STEM Skills they have used to increase their overall understanding of the importance of these skills.

A series of Project Maps for the STEM project have also been created to allow teachers and students to clearly see some of the many aspects that could be investigated as part of the project. These are included as Appendix 1. There is a full STEM project map which may be too overwhelming for some students at first so there are also a series of more focused maps (numbered 1-4) included.

This project map could be used in several ways:

- For students to choose one specific aspect of the project to work on
- For teachers to choose one branch for the class to work on as a theme for the whole class
- As a thinking prompt for any other aspects of the project that could be investigated – the project map is definitely not exhaustive!

Dust: Earth & Beyond

The Challenge

Dust is defined in the Oxford dictionary as "fine, dry powder consisting of tiny particles of earth or waste matter lying on the ground or on surfaces or carried in the air." (https://www.lexico.com/en/definition/dust)

Dust is an issue that causes problems on many scales. We're all familiar with household dust coating furniture and fittings, causing allergies and creating a nuisance in our homes but have you ever thought about problems it may cause in industry or even when we explore our solar system? This STEM project will examine dust issues in three areas – on Earth, on the Moon and on the planet Mars, and how these issues may be overcome. It is suggested that students are directed to concentrate on one of these three areas initially, however, they may find that solutions they come up with may be applied across all areas.

First, let's start with a look back at the history of space exploration and when humans first thought about landing on the Moon. Most people have an image of the Moon as being a barren, sterile environment but it is actually very dusty up there with a layer of very loose dust about 10cm thick on the surface.

One of the first steps taken on the Moon, this is an image of Buzz Aldrin's boot print from the Apollo 11 mission. Neil Armstrong and Buzz Aldrin walked on the Moon on July 20, 1969.
Image credit: NASA https://www.nasa.gov/centers/marshall/history/apollo11_140718.html

In fact, before any vehicles were landed on the moon, NASA were not sure they would be able to land as some theorised that a lunar landing module would sink into the dust layer! A robot named Surveyor allowed these fears to be set aside by landing on the lunar surface in June 1966. This and subsequent unmanned missions provided a lot of information leading to the first man, Neil Armstrong, setting foot on the Moon's surface on July 20, 1969, as part of the Apollo 11 mission.

Since the Moon has a very thin atmosphere, it has been bombarded over billions of years by meteorites. These meteorite impacts caused the formation of a kind of vapour made up of broken particles of rock that were blasted off the surface and then settled back down as dust.

The thin atmosphere also allows strong radiation from the Sun to affect these dust particles, causing them to become slightly electrically charged, making them very clingy and sticky. A bit like the way your hair will stick to a balloon that has been rubbed on it. The dust particles are also quite sharp-edged and jagged, as there is very little wind to weather the particles into smoothness, this also causes the dust to cling to objects.

As you can imagine, there was a lot of scientific interest in the Moon in the lead up to the landing and dust was not initially seen as being of great importance. It was an Australian scientist working with NASA in the lead-up to the Apollo 11 launch who convinced them to include a dust monitor in the scientific instruments to be left on the Moon.

Brian O'Brien was an expert on radiation and was training the astronauts on this topic at the time. He designed a small device, named the Dust Detector Experiment (DDE), which measured the amount of dust settling on the lunar surface and therefore also on the scientific instruments that the astronauts placed there. Professor Brian O'Brien inadvertently became an expert on lunar dust and whilst he is retired and living in Perth now, he is still consulted on the issue of dust on the Moon today.

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The last man to walk on the Moon as part of NASA's Apollo missions, Captain Gene Cernan, has been quoted as saying "dust was the biggest hazard to lunar exploration". The Apollo astronauts reported issues with the dust coating their space suits and scientific instruments, scratching their visors, and irritating their skin and lungs. It was very difficult for the astronauts to remove the dust before entering the lunar landing vehicles and inevitably a reasonable amount of lunar dust was brought back to Earth on their return from the Moon landings.

Left - Astronaut Eugene A. Cernan, Apollo 17 commander, pictured coated in lunar dust after walking on the Moon.

Image credit: NASA
images-assets.nasa.gov/image/AS17-145-22224/AS17-145-22224~orig.jpg

Right - A close-up view of the lunar roving vehicle (LRV) on the moon during the Apollo 17 mission. Astronauts Eugene A. Cernan and Harrison H. Schmitt were reporting a problem with lunar dust because of the damaged fender.

Image credit: NASA
images-assets.nasa.gov/image/as17-137-20979/as17-137-20979~orig.jpg

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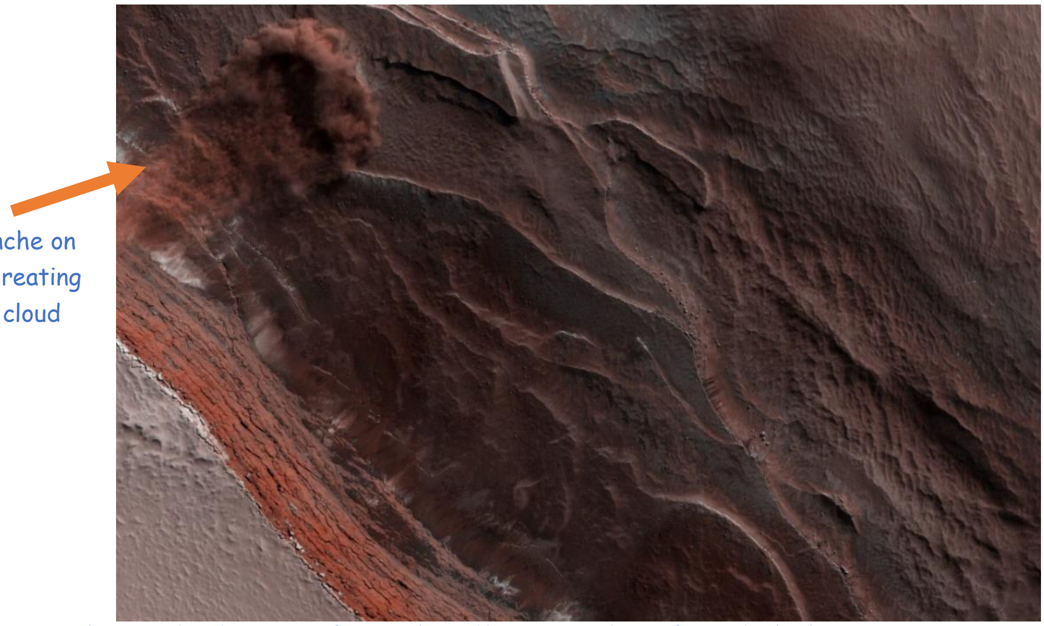
With NASA and other space agencies once again interested in exploring the Moon, and also Mars, dust in extra-terrestrial places has again been raised as an issue that needs to be overcome.

Whilst there have not yet been any manned missions to Mars, we know a lot about the surface through the data that remote sensing (telescopes and orbiters) and robotic surface rovers have provided so far. Dust will clearly be an issue to overcome, perhaps an even larger issue than on the Moon.

Mars has a much more dynamic surface than the Moon as it has more of an atmosphere and a more rugged terrain, with weathering and erosion occurring. There are seasons and weather patterns on Mars and through studying these scientists have already witnessed dust clouds from avalanches and dust storms whipped up by wind.



Avalanche on Mars creating dust cloud

Image Credit: NASA/JPL/University of Arizona https://www.nasa.gov/image-feature/avalanche-season-on-mars

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One of the most successful missions NASA has run on the Martian surface is the Opportunity rover. Opportunity was landed on the surface in January 2004 and provided some of the most comprehensive information on the minerals present there as well as evidence of liquid water being present in the past. In its more than 14-year mission, Opportunity returned more than 217,000 images and covered 45 kilometres of the Martian surface. In June 2018 however, a massive dust storm covered most of the planet Mars, coating Opportunity's solar panels, reducing its ability to generate power. This led to communication with the rover being lost and despite many attempts to restore the link, the Opportunity rover mission was abandoned.

These large, unpredictable dust storms are a huge issue for current unmanned missions and are expected to be even more of an issue when people land on Mars. At this stage, scientists have little idea why the dust storms occur when they do. The dust particles in the storms can become charged with static electricity leading to lightning strikes and can last for months, reaching high into the atmosphere. The electrostatically charged dust particles tend to stick to equipment and solar panels and this has been an issue for the robotic rovers.

Currently, solar panels are seen to be the best way to generate power on Mars as they are relatively lightweight and easy to transport, however due to this issue with dust, scientists are researching alternative energy sources. Currently they rely on natural wind events to clean the dust from solar panels however the failure of the Opportunity rover shows this is not always a reliable method. The dust penetrating, clogging and damaging mechanical systems is also an issue that needs to be overcome for any manned missions where they will be depending on life-support systems to generate oxygen and water.

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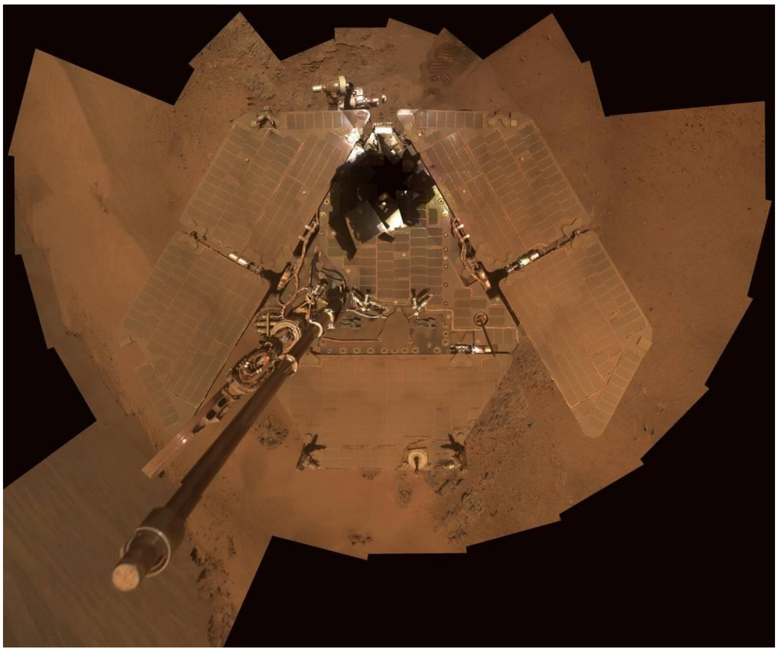

This 'selfie' taken by the Opportunity rover shows the Martian dust coating its solar panels.

Image Credit: NASA/JPL-Caltech/Cornell/Arizona State Univ.

https://www.nasa.gov/multimedia/imagegallery/image_feature_2203.html

No matter where the dust is – on the Moon, Mars or here on Earth, it can pose a risk to human health, especially when inhaled. This risk depends on two aspects: the amount of dust present and how long people are exposed to it.

Some of the Apollo astronauts reported that the lunar dust irritated their eyes and gave some of them sinus trouble. On Earth, it is well known that dust particles that are small enough to be inhaled can cause coughing, sneezing, eye irritation, hay fever and exacerbate symptoms for people with respiratory conditions such as asthma. Other issues may be caused by toxic substances contained in the dust.

Dust is considered an air pollutant and can come from varied sources including combustion (industrial and bushfires), mining operations, vehicle exhaust and erosion of soil.

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When speaking about dust as an air pollutant, it is usually spoken about using the term *particulate matter*. Particulate matter or PM is a mixture of solid and liquid particles that can be a range of shapes, sizes and contain a range of different substances – harmful and not. The size of particulate matter is measured in micrometres (one millionth of a metre with the symbol μm) and is broken into two classifications:

- PM_{10} – particles of diameter 10μm or less
- $PM_{2.5}$ – particles of diameter 2.5μm or less

When PM_{10} particulate matter is inhaled, some may make its way into your lungs, but a lot is trapped in your nose and mouth and it may also be expelled from the lungs when you breathe out or cough. $PM_{2.5}$ particulate matter can pose more of a health risk however as it can travel deeper into your lungs and be trapped there. Health authorities and governments around the world set standards and limits for the levels of PM_{10} and $PM_{2.5}$ to protect people's health.

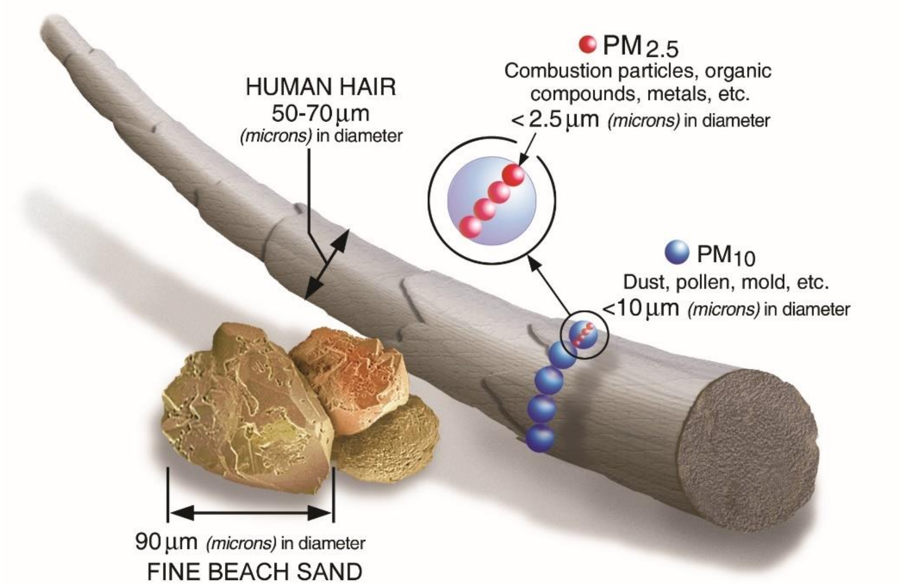

Image credit: United States EPA https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM

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Particulate matter and dust monitoring is conducted by environmental authorities (such as the Department of Water and Environmental Regulation in Western Australia) at various locations to ensure PM levels do not exceed national standards.

Industry personnel working in fields such as mining, construction and agriculture will also conduct monitoring as dust levels may form part of environmental management plans they have to meet to operate.

They may monitor air quality in an area by placing a static sampling device for a known period of time or by having personnel wear a device to sample the air they are breathing in whilst performing their work duties.

There are several methods used to monitor PM levels in air. One method measures the intensity of a beam of light passing through air, as PM present will reduce this intensity. Another method involves the collection of samples of PM in a set volume of air. This method uses filter paper that can then be weighed to determine the amount of material collected and then compared to standards. Dust can also be monitored on a much larger scale through satellite imaging from space.

Dust and other particulate matter have a detrimental effect on plants. The leaves of plants have tiny pore-like structures called stoma (plural stomata) on their leaves. Stomata allow plants to exchange gases with the atmosphere and are involved in the process of photosynthesis where plants 'breathe' in carbon dioxide and produce oxygen.

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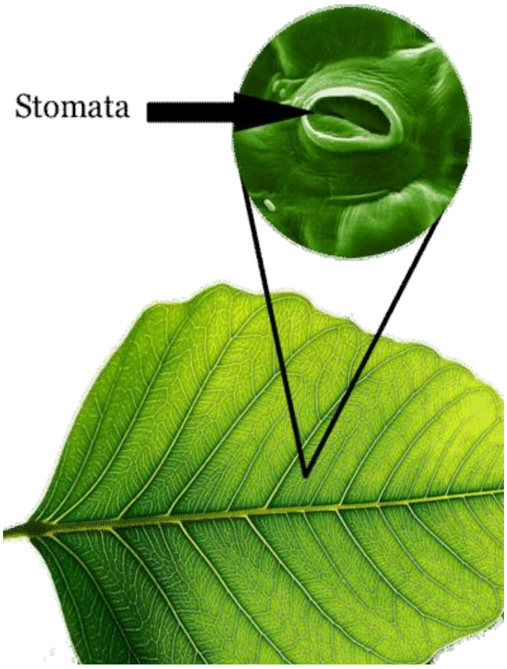

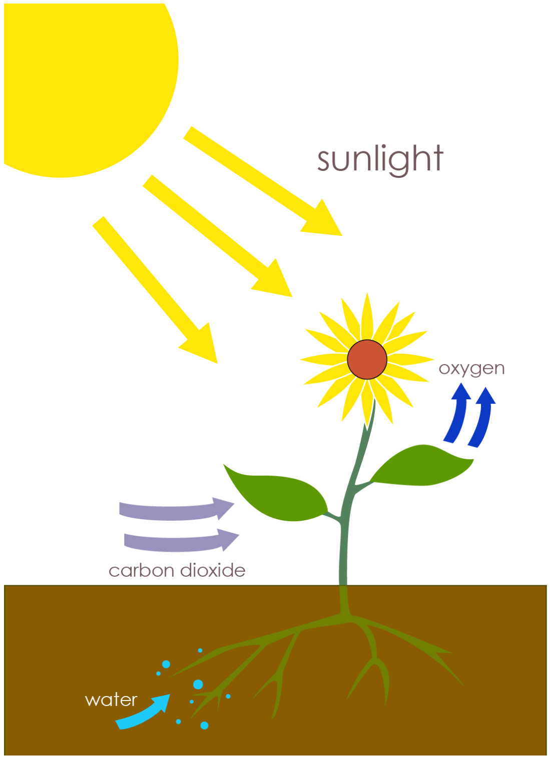

When dust coats the leaves of plants, stomata can become blocked which prevents the process of gas exchange occurring. This can lead to reduced rates of photosynthesis which may result in the plant dying. Toxic substances that attach to the dust particles, such as heavy metals, may poison plants also. It is difficult to find information online pitched at an appropriate level for students on this issue, however there are numerous scientific papers reporting research on this.

In contrast, a positive effect of dust on plants that has been noted is that dust blowing across the oceans from the Sahara Desert may help fertilise the Amazonian rainforest.

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When the issue of dust on plants is considered in the context of agriculture, food crops may fail leading to food security issues and economic impacts. As well as the health effects on plants, dust also becomes an issue when food crops are processed (such as wheat harvesting or wine making) as the dust is a contaminant, affecting quality and flavours. Issues with dust on Earth have become exacerbated in recent years with climate change affecting levels of rainfall. Areas in drought experience dust storms more frequently and the very dry top soil is more easily moved by the wind.

In September 2009 there was a very large dust storm in Eastern Australia affecting areas of NSW, the ACT and QLD. This dust storm was more than 500km in width, 1,000km in length and its intense red-orange colour was visible from space. The dust came from deserts in the interior of Australia and it caused a reduction in temperature in the areas it blanketed.

Image credit: John Byrne [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)]
https://commons.wikimedia.org/wiki/File:SHB-Red-Dust.jpg

Particulate matter concentrations during this storm reached 15,400 micrograms per cubic metre ($\mu g/m^3$) of air – a normal day has concentrations around 20 $\mu g/m^3$ with bushfires causing concentrations around 500 $\mu g/m^3$. It resulted in asthma sufferers being hospitalised, roads being closed, and flights being disrupted. Some of the dust even drifted across to New Zealand. Another dust storm of a similar size occurred in November 2018.

What can be done about dust issues then? Whether we are examining dust on the Moon, Mars or Earth, there are three main strategies to employ.

1. Prevent the dust being generated in the first place. Some strategies include:
   - changing the way industrial processes are carried out,
   - improving engine design to reduce emissions,
   - planting vegetation to bind top soil

2. Suppress the dust to prevent it spreading. This could be done by:
   - spraying roads and dirt piles with water or other chemicals
   - sealing roads
   - installing wind breaks

3. Protect organisms from the dust. This should be the last line of defence if strategies 1 and 2 are not possible and could include measures such as:
   - the use of personal protective equipment (PPE) such as dust masks and respirators
   - dust extraction systems

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As is shown in the preceding pages, dust is not a simple issue and there are many areas to investigate and many ways to deal with the issue.

This project has been broken into three main areas:

- All about dust
- Dust on the Moon and Mars
- Solving dust issues on Earth

These areas are then further broken down into smaller areas which can be seen on the STEM Project Maps 1-4 in Appendix 1.

A list of keywords used in the project is included in Appendix 2.

Links to the Australian Curriculum are shown in Appendix 3 at the end of this document. Due to the nature of this project, not all curriculum points will be covered by all students.

References used in preparing this Teacher's Guide are included in Appendix 4.

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Find Out More and Get Thinking

Students will need to know a bit more about what dust is and where it comes from. Once they have an understanding of this, they then need to find out more about dust in the three areas included in this project – the Moon, Mars and Earth. Then they can start to come up with ideas on how to deal with dust issues.

Listed below are some stimulus questions and links to articles and videos that will help inform students and get them thinking about some of the problems. You could either ask students to research one or more of these questions themselves or prepare some material yourself to present to the class.

*What is **dust**? Where does **dust** come **from**?*

- TED-Ed video introducing what dust is composed of and where it comes from. Starts at household dust and progresses to stellar dust https://youtu.be/P21a5Uty-uc
- Dictionary definition of dust https://www.lexico.com/en/definition/dust
- Wikipedia page giving general information on dust and its sources https://en.wikipedia.org/wiki/Dust
- Simple summary of sources of dust and its effects https://www.conserve-energy-future.com/causes-and-effects-of-particulate-matter.php

*What do the terms '**particulate matter**', '**PM10**' and '**PM2.5**' mean when we're talking about dust?*

- Explanation of particulate matter https://www3.epa.gov/region1/eco/uep/particulatematter.html

- Definition of PM10 and PM2.5 http://www.npi.gov.au/resource/particulate-matter-pm10-and-pm25

*What was the **Apollo Program**?*

- *Introduction to the Apollo program* https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-was-apollo-program-58.html

*Why was **lunar dust** an **issue** for the Apollo **astronauts** when visiting the Moon?*

- Video discussing issues with lunar dust https://www.youtube.com/watch?v=EFqpgmZAZgo
- Article on health issues lunar astronauts experienced https://en.wikipedia.org/wiki/Adverse_health_effects_from_lunar_dust_exposure
- Article on problems with lunar dust and how it will be a problem for future missions http://blogs.discovermagazine.com/d-brief/2018/03/02/lunar-dust/#.XbEe9SBS9PZ

*How did the **Apollo** moon missions try and **prevent** lunar **dust** being brought **in** to the **landing module**?*

- *Article mentions different methods astronauts tried* https://www.wired.com/story/moondust-nasa-lunar-ambitions/

*Who was the **Australian scientist** who **invented** the **dust monitor** to put on the **Moon**? Find out more about him.*

- *Article on lunar dust that introduces Professor O'Brien* https://www.wired.com/story/moondust-nasa-lunar-ambitions/

- Professor O'Brien's own website which includes biographical & scientific information
  https://www.brianjobrien.com/

*What happened to the **Opportunity rover** on **Mars** to cause it to **stop communicating** with Earth?*

- NASA article announcing Opportunity mission is finished
  https://www.jpl.nasa.gov/news/news.php?feature=7334
- Video explaining problems communicating with Opportunity
  https://www.youtube.com/watch?v=LkAHm4KpcJY

*What do we currently know about the **dust storms** on **Mars**? What **research** is being done?*

- Videos detailing research being done on Mars dust storms
  https://www.youtube.com/watch?v=JKBk_Kfucs4
  https://www.youtube.com/watch?v=I4DNVKx8IDM

*How **far** can dust on **Earth travel**?*

- NASA video explaining how dust from the Sahara Desert is being deposited in the Amazon rainforest
  https://youtu.be/ygulQJoIe2Y

*How does **dust** affect **human health**?*

- WA Health Department information page on health effects of dust
  https://healthywa.wa.gov.au/Articles/F_I/Health-effects-of-dust
- Victorian Health Department information on dust, including health effects
  https://www2.health.vic.gov.au/public-health/environmental-health/climate-weather-and-public-health/airborne-dust

*What are **dust levels** like in **Western Australia**?*

- West Australian Department of Water & Environmental Regulation page where data on air quality monitoring at sites around Perth can be viewed.
  https://www.der.wa.gov.au/your-environment/air/air-quality-data
- Live air quality data (updated hourly) for today in Perth
  https://www.der.wa.gov.au/your-environment/air/air-quality-index

*What **happens** during a large **dust storm**? Do we get **dust storms** in **Australia**?*

- News article on dust storm on east coast of Australia
  https://www.kidsnews.com.au/weather/grey-dust-storm-the-length-of-nsw-blankets-canberra-and-then-sydney-as-it-heads-towards-the-sea/news-story/8ba4a0c0efa994761eef89fb3a4d453b
- Wikipedia page on large dust storm in 2009
  https://en.wikipedia.org/wiki/2009_Australian_dust_storm
- Images of dust storms in Australia
  https://commons.wikimedia.org/wiki/File:Sydney_Dust_Storm_6am.JPG
  https://commons.wikimedia.org/wiki/File:SHB-Red-Dust.jpg#filelinks
- ABC news report on dust storm in Sydney, November 2018
  https://www.youtube.com/watch?v=ADpq0hjbbCA
- BBC news report on dust storm in Mildura, Victoria, May 2019
  https://www.youtube.com/watch?v=hOQC7x0_6oA

*What **effect** does **dust** and **particulate matter** have on the **environment**, particularly **plants**?*

- Article giving brief explanation of environmental impacts
  https://foobot.io/guides/environmental-impact-of-particle-pollution.php

- NASA article discussing study on effect of particulate matter on plants absorbing carbon. https://www.nasa.gov/vision/earth/environment/aerosol_carbon.html

*What are some of the different **ways** that **dust levels** can be **monitored**?*

- Animation showing movement of dust particles based on satellite data and computer models https://youtu.be/DBkzCCfrQXE
- Fact sheet containing information on dust and dust monitoring (different methods of monitoring on page 6) https://d3n8a8pro7vhmx.cloudfront.net/edonsw/pages/688/attachments/original/1430710667/Technical_-_Air_Quality.pdf?1430710667
- Queensland government web page explaining different devices for measuring dust levels https://www.qld.gov.au/environment/pollution/monitoring/air/air-monitoring/measuring

A STEM project research worksheet has been provided in the student booklet. This gives students the opportunity to consider and research the broader issues. If you have chosen a particular section of the broader STEM project map, this should be the focus of their research.

Ways to Meet the Challenge

Before starting to work on meeting the challenge, it is important that students are very clear on what specific problem they are going to be solving. So they can limit the scope of their project and make it achievable.

As previously mentioned, this project has been broken into four main areas:

- All about dust
- Dust on the Moon and Mars
- Solving dust issues on Earth

You may like to ask students to choose one of these areas (or assign them one) or perhaps tell the class that they will all be working on one of these three areas and assign each group a more specific point to work on, collaborating with other groups to solve the main problem as a class.

At this stage, students should spend **at least one lesson** brainstorming and refining their ideas. If possible, it would be good to spend another lesson on this step before allowing the students to move on. It should be stressed that thinking through and refining their ideas is a really important step that should be given enough time as they will be very keen to jump in and start building things or doing experiments. Thinking more about the way they can solve a problem will help them to understand the problem more fully, which will ultimately lead to a better solution, and it is a more efficient use of resources.

Once they have thoroughly thought through a possible solution to their problem, they may then move on to building prototypes, designing experiments, testing and reviewing. This process is likely to take several lessons, but it is also important to give students clear deadlines they must meet to enhance their chances of finishing the project.

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Remind students that prototypes do not need to be perfect and are a representation of what a final product may look like. For some sections listed, the students may not be able to make a working prototype but may produce a detailed diagram or map to illustrate their solution. Some students may need to carry out some trials or experiments. For example, by growing plants to test their ideas on aspects such as the amount of dust plants are exposed to and protection methods. This will obviously take a longer period of time so it may not be possible to work on the project continuously.

Below we have listed some prompts for a couple of the areas in the STEM Project Map for the Dust: Earth & Beyond Challenge to give an idea of how projects may be structured. As mentioned previously, students may come up with other areas they would like to investigate. Not all areas have been expanded like this to allow teachers some freedom in tailoring the project to their students.

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1. All about dust

How are plants affected by dust?

- Investigate the features of plants growing in different environments around the world and how they adapt to dust levels
- Design and conduct an experiment to test how plants respond to different levels of dust in their environment
- Conduct a survey of dust levels on the plants in your local area by wiping their leaves. Also record what kind of leaves they have and how healthy the plant is
- Investigate stoma on leaves and how dust may affect how they work

Other areas within this topic to consider include:

- Measuring plant growth or oxygen production levels when exposed to dust
- Examining the size of stoma in different plants

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Monitoring dust levels

- Research different instruments used to monitor dust levels
- Investigate dust levels at your school. Which area is the most dusty and where is the dust coming from?
- Create a database of PM2.5 and PM10 levels in an area and design a way to communicate this information to the general public
- Design and test your own dust monitor

Other areas within this topic to consider include:

- Dust monitoring using satellites
- Dust monitoring using light sources or lasers
- Working with a local authority or industry to find out more about their dust monitoring and perhaps to help them

2. Dust on the Moon & Mars

Efficiency of solar panels

- Investigate how the efficiency of solar panels powering a solar car changes with dust levels
- Design a method for preventing dust collecting on solar panels
- Design and conduct an experiment to examine the damage caused by dust storms to solar panels
- Design and test a way to clean dust from solar panels

Keep in mind the context of these solar panels being on the Moon or Mars so remote or robotic operation should be considered.

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Vehicle design for driving in dust

- Consider the materials vehicles on the Moon or Mars could be made of to prevent dust coating
- Design and test wheels and/or tyres suitable for driving on the Moon or Mars
- Consider what kind of scientific instruments should be carried by a vehicle and how to protect them from dust
- Design and test a solar powered rover to operate in dusty conditions

Other areas within this topic to consider include:

- Design of vehicle to protect astronauts from dust whilst driving
- Whether wheels or tracks are better for driving in dust
- Investigate effect of the weight of the vehicle when driving in dust
- Use light sensors on robots to investigate visibility in dust storms

3. Solving dust issues on Earth

Effectiveness of dust protection

- Investigate ways that people may protect themselves from dust
- Conduct a trial of different devices to find most effective form of protection from breathing in dust of different sizes
- Design a method to protect plants from dust in the air
- Design and build a device to prevent dust in the air being breathed in

Other areas within this topic to consider include:

- Design of industrial dust extraction systems

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Dust behaviour on different surfaces

- Investigate different coatings that could be applied to surfaces to stop dust sticking
- Investigate what is the best fabric for clothing that dust will slide off rather than stick to
- Consider how static electricity can change how dust behaves on different surfaces
- Design and conduct an experiment to test how dust behaves on some different building materials

Other areas within this topic to consider include:

- Investigate how the smoothness of a surface affects the amount of dust that sticks

Could It Be Better?

Once students have fully examined the challenge and come up with their solutions, they should then spend some time reviewing their solution to come up with ways it may be improved. There are always restrictions on what students can achieve in a classroom setting due to time, space, budget and equipment availability, so ask the students to think about their solution if they were to be given unlimited resources. The obvious limitations in this particular project are the ability to explore their solution on the Moon or Mars – being able to test the affects of differing gravity, atmosphere and solar radiation.

Aspects for the students to consider to try and put their solution in a real world context:

- Availability of resources – do you have access to enough of the materials? Is there enough of it available in Australia? On Earth?
- Will current technology be useful, or do you need something more?
- Estimate how much would it cost to put your plan in place.
- Estimate how long would it take to put your plan in place.
- Can you do all of this yourself or do you need to bring in some experts? Who might these experts be?
- Did your experiments or tests give you enough information to start to solve the problem tomorrow? What further experiments or tests might you need to do?

Report Back to Base

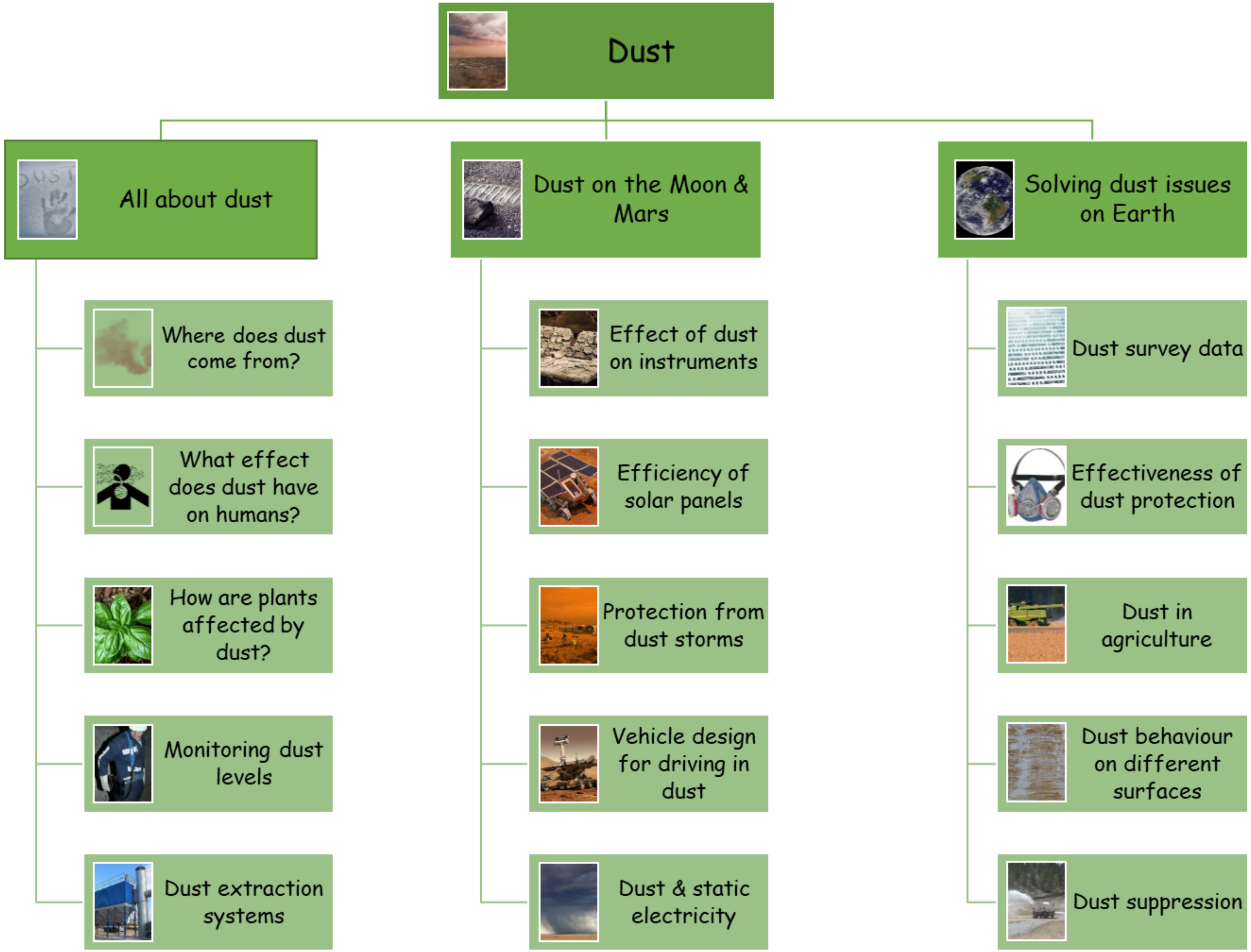
To finish up the Dust: Earth & Beyond STEM Project, students should present their findings back to the class or perhaps even to the school or a wider audience! There are many ways this can be done such as written reports, posters, a STEM Fair, oral presentations, at a parent evening or as a short film. The mode the students use to communicate their findings may also fit into another curriculum area such as English or Digital Technologies.

It is also worth considering if the student's projects would be eligible for entry in one of the many Science and STEM competitions available. Check with your local science teacher's association or community group about competitions or consider national programs such as the CREST (Creativity in Research, Engineering, Science and Technology) Awards run by CSIRO.

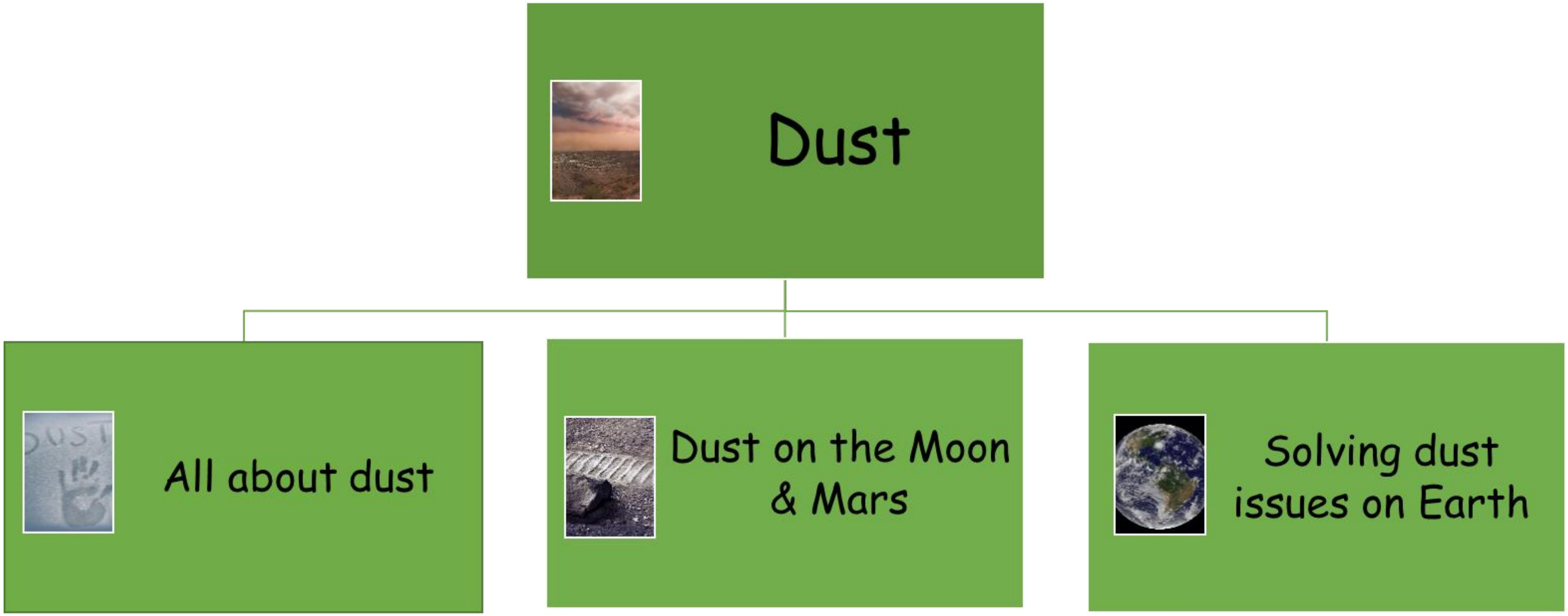
Students should cover the following points in presenting their findings:

- What have we found out or discovered that we didn't know before?
- What did we design, build, program, test etc.?
- What STEM skills have we used? (problem solving, creativity, critical analysis, teamwork, independent thinking, communication, digital literacy)
- What data did we generate in our investigation and what does this show? (this may be in the form of tables or graphs and may not be relevant to every section of the project)
- How could we better investigate the challenge if we had no limit on resources or time?
- What was the most challenging aspect of the project?

Appendix 1: Full Project Map



STEM Project Map 1



STEM Project Map 2

All about dust

Where does dust come from?

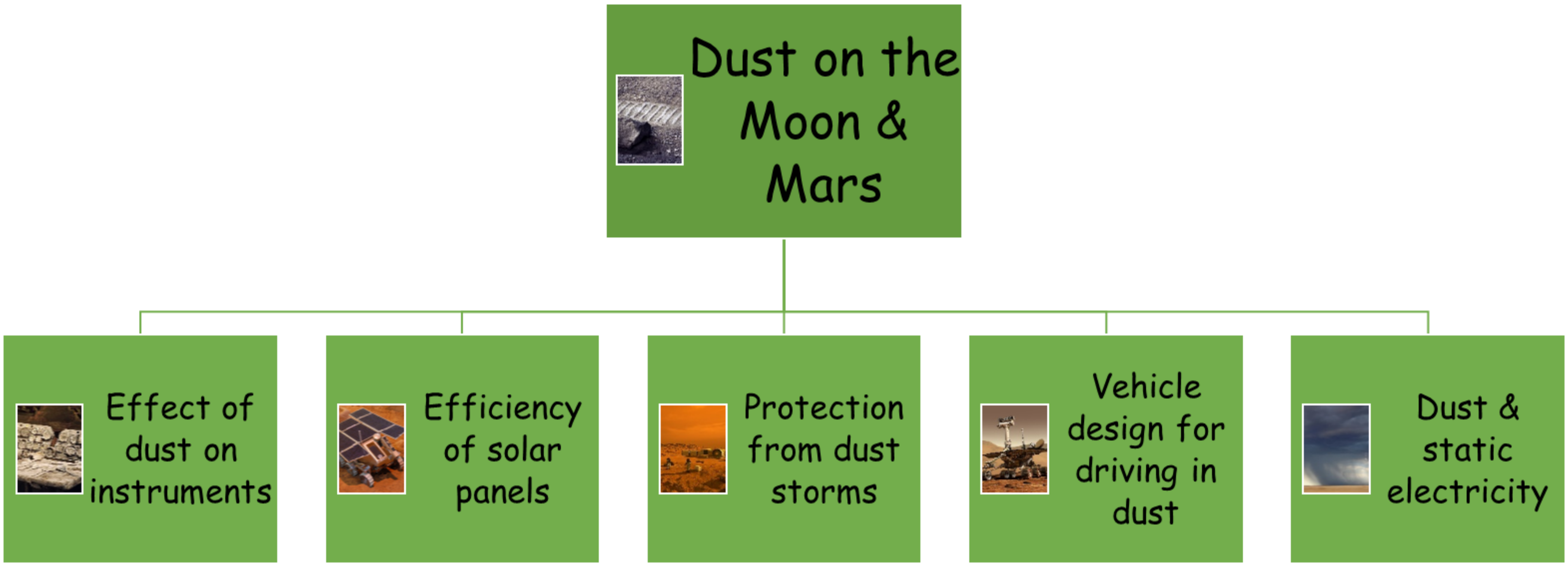
What effect does dust have on humans?

How are plants affected by dust?

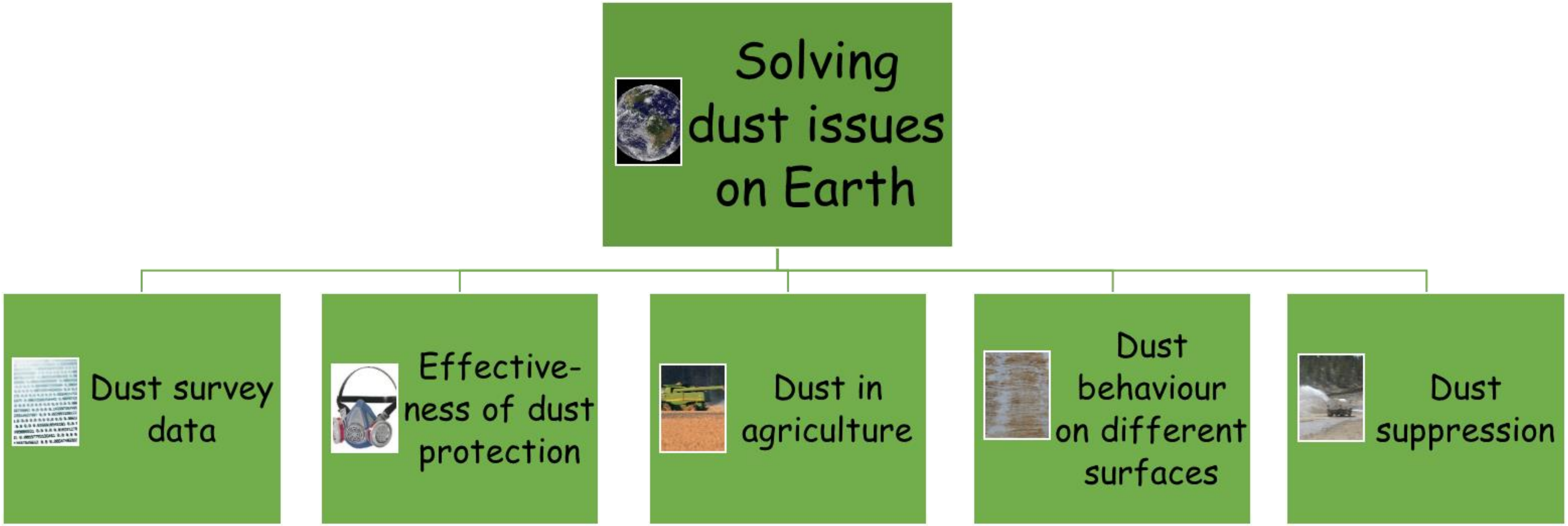
Monitoring dust levels

Dust extraction systems

STEM Project Map 3



STEM Project Map 4



Appendix 2

Dust: Earth & Beyond Project Keywords

particulate matter	dust storm	static electricity
dust	lunar	electrostatic
particles	lunar lander	lightning
PM10 / PM2.5	landing module	data
micrometre (μm)	meteorite	protection
pollutant	Martian	adaptation
monitor	rover	stoma/stomata
detect	solar panel	photosynthesis
dust extraction	scientific instrument	health effect
survey	surface	drought
filter	efficiency	environmental effect

Appendix 3

Year 5 Australian Curriculum links

<u>Note</u>: All curriculum areas may not be covered by each student depending on how the project is organised and assigned.

Science	Technology*	Engineering*	Mathematics
Science Understanding Biological Sciences Living things have structural features and adaptations that help them to survive in their environment (ACSSU043) Chemical sciences Solids, liquids and gases have different observable properties and behave in different ways (ACSSU077) Earth and Space Sciences The Earth is part of a	**Technologies and Society** How people address competing considerations when designing products, services and environments (ACTDEK019) **Food and fibre production** People in design and technologies occupations aim to increase efficiency of production	**Engineering principles and systems** Forces can control movement, sound or light in a product or system (ACTDEK020) **Materials and technologies specialisations** Characteristics and properties of a range of materials and components, and the suitability	**Number and Algebra** Use efficient mental and written strategies and apply appropriate digital technologies to solve problems (ACMNA291) Recognise that the place value system can be extended beyond hundredths (ACMNA104) Compare, order and

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system of planets orbiting around a star (the sun) (ACSSU078) Physical Sciences Light from a source forms shadows and can be absorbed, reflected and refracted (ACSSU080) **Science as a Human Endeavour** Nature and development of science Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE081)	systems, or consumer satisfaction of food and natural fibre products (ACTDEK021) **Digital systems** Digital systems have components with basic functions and interactions that may be connected together to form networks which transmit different types of data (ACTDIK014) **Producing and implementing** Select, and apply, safe procedures when using a variety of components and	and safe practice of their use (ACTDEK023) **Investigating and defining** Define a problem, and set of sequenced steps, with users making a decision to create a solution for a given task (WATPPS27) Identify available resources (WATPPS28) **Designing** Develop and communicate alternative solutions, and	represent decimals (ACMNA105) **Measurement and Geometry** Choose appropriate units of measurement for length, area, volume, capacity and mass (ACMMG108) Use a grid reference system to describe locations. Describe routes using landmarks and directional language (ACMMG113)

Use and influence of science Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083) **Science Enquiry Skills** Questioning and predicting With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS231) Planning and conducting Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using	equipment to make solutions (WATPPS30) **Representation of data** Data is represented using codes (ACTDIK015) **Collecting, managing and analysing data** Collect, store and present different types of data for a specific purpose using software (ACTDIP016) **Digital implementation** Design, follow and represent diagrammatically a	follow design ideas, using annotated diagrams, storyboards and appropriate technical terms (WATPPS29) **Collaborating and managing** Work independently, or collaboratively when required, to plan, develop and communicate ideas and information for solutions (WATPPS32)	**Statistics and Probability** Pose questions and collect categorical or numerical data by observation or survey (ACMSP118) Construct displays, including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies (ACMSP119) Describe and interpret different data sets in context

equipment and materials safely and identifying potential risks. (ACSIS086) Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate (ACSIS087) Processing and analysing data and information Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns	simple sequence of steps (algorithm), involving branching (decisions) and iteration (repetition) (ACTDIP019) Implement and use simple programming environments that include branching (decisions), iteration (repetition) (ACTDIP020)		(ACMSP120)

or relationships in data using digital technologies as appropriate (ACSIS090) Evaluating Reflect on and suggest improvements to scientific investigations (ACSIS091) Communicating Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS093)			

*Drawn from Design and Technologies and Digital Technologies curriculum

Links to other curriculum areas

Humanities and Social Science (HASS)

- The way people alter the environmental characteristics of Australian places (e.g. vegetation clearance, fencing, urban development, drainage, irrigation, farming, forest plantations, mining) (ACHASSK112)
- Features of environments (e.g. climate, landforms, vegetation) influence human activities and the built features of places (ACHASSK113)
- The impact of bushfires or floods on environments and communities, and how people can respond (ACHASSK114)
- Locate and collect information and/or data from a range of appropriate primary sources and secondary sources (e.g. museums, media, library catalogues, interviews, internet) (WAHASS52)
- Record selected information and/or data using a variety of methods (e.g. use graphic organisers, paraphrase, summarise) (WAHASS53)
- Use ethical protocols when gathering information and/or data (e.g. acknowledge the work of others, reference work appropriately, obtain permission to use photographs and interviews) (WAHASS54)
- Use criteria to determine the relevancy of information (e.g. consider accuracy, reliability, publication date, usefulness to the question) (WAHASS55)
- Interpret information and/or data collected (e.g. sequence events in chronological order, identify cause and effect, make connections with prior knowledge) (WAHASS56)

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- Draw and justify conclusions, and give explanations, based on the information and/or data in texts, tables, graphs and maps (e.g. identify patterns, infer relationships) (WAHASS59)
- Use decision-making processes (e.g. share opinions and personal perspectives, consider different points of view, identify issues, develop possible solutions, plan for action, identify advantages and disadvantages of different options) (WAHASS60)
- Reflect on learning, identify new understandings and act on findings in different ways (e.g. suggest additional questions to be investigated, propose a course of action on an issue that is significant to them) (WAHASS63)

English

- Understand the use of vocabulary to express greater precision of meaning, and know that words can have different meanings in different contexts (ACELA1512)
- Plan, rehearse and deliver presentations for defined audiences and purposes incorporating accurate and sequenced content and multimodal elements (ACELY1700)
- Navigate and read texts for specific purposes applying appropriate text processing strategies, for example predicting and confirming, monitoring meaning, skimming and scanning (ACELY1702)
- Use comprehension strategies to analyse information, integrating and linking ideas from a variety of print and digital sources (ACELY1703)

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- Use a range of software including word processing programs with fluency to construct, edit and publish written text, and select, edit and place visual, print and audio elements (ACELY1707)

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Appendix 4

References used in preparing this project

https://www.nasa.gov/ - images and information

https://mars.nasa.gov/mer/

https://www.brianjobrien.com/

http://www.corehub.com.au/blogpost/the-moon-dust-challenge

https://www.wired.com/story/moondust-nasa-lunar-ambitions/

http://blogs.discovermagazine.com/d-brief/2018/03/02/lunar-dust/#.XRweNiBS9aQ

https://www.sciencedaily.com/releases/2008/09/080924191552.htm

https://en.wikipedia.org/wiki/Adverse_health_effects_from_lunar_dust_exposure

http://www.npi.gov.au/resource/particulate-matter-pm10-and-pm25

https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM

https://www.der.wa.gov.au/your-environment/air/air-quality-data

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https://www2.health.vic.gov.au/public-health/environmental-health/climate-weather-and-public-health/airborne-dust

https://en.wikipedia.org/wiki/2009_Australian_dust_storm

https://d3n8a8pro7vhmx.cloudfront.net/edonsw/pages/688/attachments/original/1430710667/Technical_-_Air_Quality.pdf?1430710667

https://biooekonomie.de/en/nachrichten/fine-dust-dries-out-trees

https://medcraveonline.com/HIJ/responses-in-plants-exposed-to-dust-pollution.html

https://www.sciencedirect.com/science/article/pii/0143147184900564

https://dec.alaska.gov/air/anpms/dust/control-techniques/

https://fortress.wa.gov/ecy/publications/publications/96433.pdf

https://en.wikipedia.org/wiki/Dust

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Videos

https://www.youtube.com/watch?v=EFqpgmZAZgo Apollo, the Lunar Dust and NASA's Dirty Problem

https://www.youtube.com/watch?v=RKr-z5RS8uA Unsealing Gene Cernan's life support cover for preservation

https://www.youtube.com/watch?v=-qEwrRGwW2I Moon dust and dirt

https://www.youtube.com/watch?v=LkAHm4KpcJY Opportunity rover stuck in dust storm

https://www.youtube.com/watch?v=JKBk_Kfucs4 Mars mega dust storms

https://youtu.be/ygulQJoIe2Y NASA video explaining dust from Sahara Desert being deposited in Amazon rainforest