STEAM EDUCATION FOR SUSTAINABLE DEVELOPMENT and FUTURES LITERACY

SGD9 Future of Space

Programme Phase 2: Experimentation and Exploration

Micro-Module 4: Space Innovation and Enterprsise

SUBJECT AREAS: CSPE/ SPHE, Design, English and Communication, Environment, Science, Sustainability, Technology

8 DECENT WORK AND ECONOMIC GROWTH

10 REDUCED INEQUALITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

17 PARTNERSHIPS FOR THE GOALS

SFI Discover Science Foundation Ireland

An Roinn Oideachais Department of Education

SDG 9 Future of Space
MM4: Space Innovation and Enterprise

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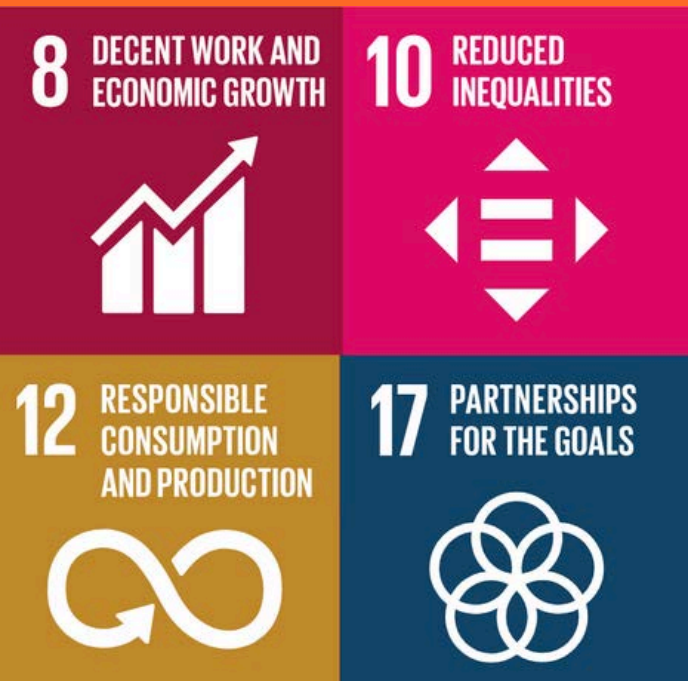
Experimentation and Exploration

Curriculum Areas

CSPE/ SPHE, Design, English and Communication, Environment, Science, Sustainability, Technology



In this module learners, will explore the intersection of space entrepreneurship and the myriad of career opportunities available in the space industry. With the onset of the commercialisation of space, the burgeoning field of space tourism, the potential of resource mining increases the potential of space as a marketplace for goods, services, and innovation.

Through hands-on activities, real-world examples, and interactive discussions, learners will gain insights into the future possibilities and educational pathways in space-related fields.

This module will support learners to develop a deeper understanding of the commercial aspects of space exploration, gain exposure to diverse career options in the space industry, offering inspiration to pursue their passions in STEAM fields with a focus on space entrepreneurship.

In this module, the learner will...

- gain an understanding of the commercialisation of space
- explore space entrepreneurship and emerging opportunities
- examine inclusion in the space industry
- become aware of open-source space exploration
- gain insights into the impact of space tourism
- explore career pathways in the space industry
- envision future possibilities in space exploration and entrepreneurship

This module includes:

- Lesson plans and accompanying resources
- Optional assessments
- Skill support resources

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Lesson 1: The Commercialisation of Space
In this lesson, learners are introduced to the commercial space industry, its key players, and ventures in space entrepreneurship, and to explore space as a marketplace for goods, services, and innovation.

Resources: Worksheets: Space Commercialisation Overview, Space Venture Remix Grid, Teacher's Guide: Space Commercialisation Overview

Lesson 2: Develop a Space Venture Idea
This lesson enables students to develop an understanding of the process of generating ideas starting with the Space Venture Remix Grid and then using the remix method to develop their own Space Venture idea.

Resources: Worksheets: Space Venture Remix Grid, Space Venture SWOT Analysis Teacher's Guide: Space Commercialisation Overview

Lesson 3: Space Entrepreneurship
In this lesson, learners will explore the entrepreneurial aspects of commercialising space, including identifying opportunities, overcoming challenges, considering the implications and developing innovative business solutions.

Resources: Worksheet: What is Space Entrepreneurship? Teacher's Guide: What is Space Entrepreneurship?

Lesson 4 - 6: Inclusion in the Space Industry 1 - 3
In these three linked lessons, learners will consider the importance of diversity and inclusion in space entrepreneurship, with a focus on the participation of women, indigenous communities, people of colour, and differently-abled individuals. The lessons collectively highlight challenges and opportunities of promoting inclusive practices in space-related industries, identifying the barriers that marginalised groups face and considering ways to overcome them.

Lesson 4: Focuses on Female Space Professionals
Resources: Worksheets: Female Space Professionals, Planning Your Poster, Teacher's Guide: Female Space Professionals

Lesson 5, focuses on showcasing Indigenous and People of Colour Space Professionals
Resources: Worksheets: Indigenous and People of Colour Professionals , Planning Your Poster, Teacher's Guide: Indigenous and People of Colour Space Professionals

Lesson 6: Focuses on Differently Abled Space Professionals
Resources: Worksheets: Differently-Abled Space Professionals, Planning Your Poster, Teacher's Guide: Differently-Abled Space Professionals

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Lesson 7: Exploring Open Innovation in Space
This lesson introduces the concept of open-source space entrepreneurship and innovation. Learners will examine initiatives driving innovation and democratising access to space technology and resources by looking at real-world examples.

Resources: Worksheet: Open Innovation in Space, Open Innovation in Space - Projects, Teacher's Guide: Open Innovation in Space

Lesson 8: Space Tourism
In this lesson, learners will get an overview of the emerging Space Tourism sector, examining current and future possibilities for civilian space travel and reflect on the ethical considerations and challenges in commercialising space for tourism.

Resources: Worksheets: Engineering Space Tourism, Teacher's Guide: Engineering Space Tourism

Lesson 9: Space Tourism 2 - Create your own Space Tourism event
In this lesson, learners will build upon their previous knowledge to develop a space venture focused on civilian space travel. They will collaborate to define the aims and objectives of their space tourism event, considering factors such as target audience, mission profile, and ethical considerations.

Resources: Worksheets: Creating a Space Tourism Event, Peer review: Creating a Space Tourism Event, Teacher's Guide: Enterprise Planning, Lesson 10

Lesson 10: Space Related Careers
In this lesson, learners are introduced to the range of career paths within the space industry. Through exploration and discussion, they gain insight into diverse roles such as aerospace engineering, astrophysics, space medicine, and space entrepreneurship.

Resources: Worksheets: Generating a Space Tourism Logo, Planning a Space Tourism Venture Lean Canvas, Teachers Guide: Dragon's Den Event

Lesson 11: Future Possibilities in Space Exploration and Entrepreneurship
In this lesson, learners will explore future trends and developments in space entrepreneurship, examining the potential societal and economic impacts of space innovation.

Resources: Worksheet: Exploring Space Careers Challenge

Lesson 12:
In this lesson, learners will explore future trends and developments in space entrepreneurship, examining the potential societal and economic impacts of space innovation.

Resources: Worksheet: Considering the possibilities of the future Space Industry, continued next page

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Resources: Start up Space Venture, Teaching Guide: Setting up a Start-up Hub in a School

Module concept, design and and development: Dr. Anita McKeown
Peer review, recommendations and contributions: Rebecca White and Dr Jessica Garska

Using the Resources:
If you wish to use these resources, we can offer an induction and online support throughout the module to help you plan integration into your projects and timetable. To register for this option, please contact us e:hello@futurefocus21c.com For more information on the resources please visit www.muinincatalyst.com

Setting up an online learning environment for the lessons on this module:
Our lessons integrate the use of virtual learning environments. To ensure seamless use of our lessons, a module should be setup on your school's virtual learning environment such as Teams, Google Classroom, etc. Learners are encouraged to upload documents to share with their peers. If your virtual learning environment does not support document sharing, we recommend OneDrive or Google Drive.

You can also use Google Sites or Microsoft Sway to encourage learners to present their work over the year - this can easily be set up to reflect the aims of TY and provide a showcase for their work as well as an assessment tool.

Setting up a Canva Education account.
As our lessons integrate design, our lessons also refer to Canva. Educators and schools are able to open a free Canva for Education account by registering here: https://www.canva.com/education/ Canva for Education provides primary and secondary school teachers and students with premium features and templates. You can then also set up lessons and invite your learners to the class.

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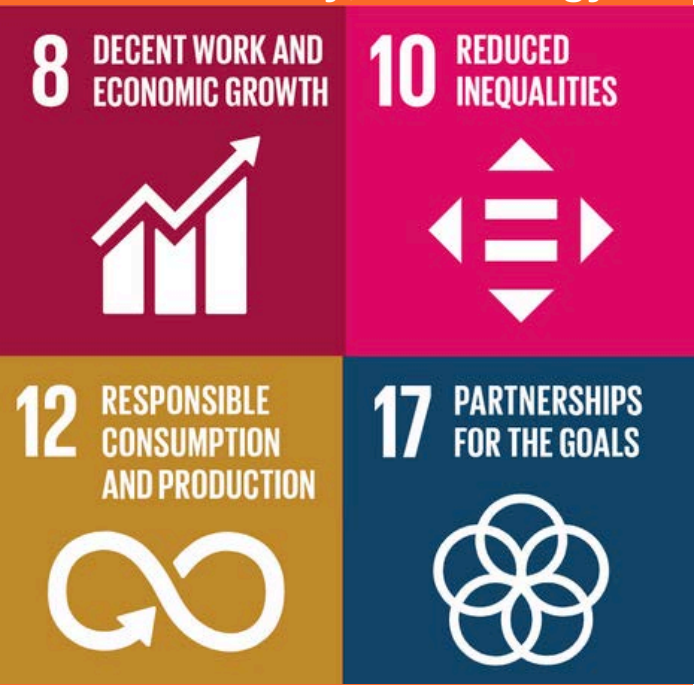
Experimentation and Exploration

Lesson 1 Introducing the Commericalisation of Space

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Introducing the Commercialisation of Space

In this lesson, learners are introduced to the commercial space industry, its key players, and ventures in space entrepreneurship and explore space as a marketplace for goods, services, and innovation.

The lesson will support learners to define and explain the concept of the commercialisation of space exploration, and begin to identify the motivations behind companies' interest in investing in space ventures.

Through this lesson, learners will develop an understanding of the commercial aspects of space exploration and begin to explore the diverse career opportunities available in the space industry.

Vocabulary: Commercialisation, Emergent Impact, Innovation, Ventures

In this lesson, the learner will:

- develop an understanding the concept of commercialisation in space exploration:
- identify key players and ventures in the commercial space industry
- understand the contributions to advancing space exploration
- begin to explore space and the emerging opportunities and implications for developing goods, services and innovation in space
- will develop their creativity, innovation, and critical-thinking skills

Materials

- Worksheet: Commercial Space Sectors Overview
- Worksheet: Space Venture Remix Grid
- Teacher's Guide: Space Commercialisation
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L1 Introducing the Commercialisation of Space

Activity Instructions

Activity 1: What is the Commercialisation of Space? (25 mins)

1. Write on the board or project the following definition of commercialisation - 'as the process of introducing a new product or service into the market to make a profit'.
2. Explain that now private companies have enough money, space exploration is no longer only possible for government, military or academic institutions, this has opened up opportunities for private companies. This means more opportunities for governments and private companies to work together to make space profitable and ideally equitable.
3. Watch Video: 'Commercialisation of Space' [3:26 mins]
4. Working in pairs, ask learners to come up with two reasons why companies are interested in investing in space exploration ventures.
5. Ask pairs to share one of their two reasons, and add their reasons to a circulating piece of paper. One of the pair can share while the other is writing down their reasons and ask learners to try to keep all the answers on 1 page
6. Go around the class, asking for new reasons until all pairs have given one reason or their reasons have been covered by someone else.
7. Ask the class to add any reasons not yet shared.
8. Use an overhead projector or photograph and upload to the class computer for projection

Activity 2 Introduction to the Commercial Space Industry (25 min)

1. Project the findings from activity 1, and working in pairs, ask learners to complete Worksheet: 'Commercial Space Sector Overview' using the learning from activity 1 and internet searches.
2. Ask learners to work with another pair to share and discuss their findings.
3. Learners will continue working in groups of four, and using their shared ideas from the Worksheet: 'Commercial Space Sector Overview' complete the Worksheet: Space Venture Remix Grid'
4. Ask for four of the groups to each share an answer for one of the boxes.
5. Use the 4 answers to brainstorm, as a class an additional or potential goods, services, or innovations that could be offered in the space marketplace. See Teacher's Guide for instructions

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

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L1 Introducing the Commercialisation of Space

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson: complete Activity 1 only and have learners upload their reasons to a shared document in the e-class room for this module as well as to their e-portfolios in Microsoft Teams or other class repository

Extension: For a longer lesson: as a class, summarise the key concepts covered in the lesson and encourage learners to reflect on what they have learned about the commercialisation of space and the opportunities it presents. Ask learners to consider the social, environmental and economic implications of space exploration and begin to identify positive and negative impacts. See Teacher's Guide for example discussion questions. Resources from MM2: Space Leadership for the 21st Century can also support this activity.

If not doing lesson 2, the Space Venture Remix Grid can be using different needs to complete worksheet e.g. completing the four boxes using different needs and then use step 4 and 5 of activity 2 to define the parameters that learners can then will work on in their own groups. This introduces learners to ideation while they can see how many possibilities can be generated with one set of variables. - see also media box video: 'Design Thinking Ideate'

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Commercialisation of Space [3:26 mins] https://www.youtube.com/watch?v=N7hKPnHwf_A

Space Foundation - Non-Profit https://discoverspace.org/about/about-the-space-foundation/

Article: The commercialisation of outer space
https://www.nortonrosefulbright.com/en/knowledge/publications/102a426e/the-commercialisation-of-outer-space#section3

Design Thinking Ideate [4:03 secs] https://www.youtube.com/watch?v=zbLxs6te5to

Local Trip / Expertise / Additional Work and Assessments

For a larger assessment project, use resources from Lesson 11 and 12 or MM7: Space Design Problem to Pitch to support learners to develop a venture idea that emerged in the Space Venture Remix Grid and present to the class.

For a smaller project, use the questions in the Teacher's Guide to create a research project for the class - allocating the questions across small groups. Learners can present their findings using SDG 12 Future of Innovation and Enterprise, MM7: Media Communication module 1 - 4.

MM4: L1TG SPACE COMMERCIALISATION OVERVIEW

Activity 2 Overview of Space Commercialisation

INDUSTRY	SHORT DESCRIPTIONS
Satellite communications	The use of satellites to transmit data, voice, and video across long distances for global telecommunications networks.
Launch services	Companies that provide the technology and logistics to send spacecraft, satellites, and payloads into space
Satellite imaging	Capturing Earth's surface and space imagery through satellites for applications such as mapping, environmental monitoring, and security.
Space-based manufacturing	The production of goods and materials in microgravity environments, offering unique advantages like precision and efficiency.
Space tourism	Commercial space travel experiences for private individuals, allowing non-astronauts to visit space.
Asteroid mining	The extraction of valuable minerals and resources from asteroids for use on Earth or in space-based industries.
Space Food and Nutrition	The development and provision of sustainable, nutritious food systems to support human life in space environments
Space Tech: Travel and Transportation	Innovations in spacecraft and propulsion systems to enable human and cargo transport in space
Space Clothing and Personal Protective Equipment (PPE)	Specialised attire and protective gear designed to safeguard astronauts from the harsh conditions of space
Space Shelter and Habitats	Structures and habitats designed for sustaining human life during space exploration, whether on spacecraft, the Moon, or Mars

MM4: L1TG SPACE COMMERCIALISATION OVERVIEW

INDUSTRY	DESCRIPTION
Space Technology - Data Services / Communication	Advanced technologies for handling data transmission, storage, and communication between space and Earth.
Space Healthcare / Medical Services	The development of medical technologies, treatments, and protocols tailored to the unique health challenges faced by humans in space.
Space Tech: Energy / Power Generation	Technologies for generating and harnessing energy in space, such as solar power and nuclear energy for spacecraft and space colonies
Space Tech: Environmental Monitoring and Resource Management	Technologies to monitor and manage environmental conditions and resources, both on Earth and in space, for sustainable exploration.

ACTIVITY 2 SPACE VENTURE REMIX GRID

Instructions for Using the Worksheet: Space Venture Remix Grid

Explain learners will use generate the answers to the boxes using the completed table for activity 1 to understand how to develop ideation skills and creative problem-solving skills

1. Organise learners into groups of 4 and ask learners to complete the worksheet: Space Venture Remix Grid by brainstorming to place an answer in each box

- Select one of the industries from the table they completed in activity e.g Space Food and Nutrition
- Write their selection in the Space Industry / Challenge theme box and think about what are the challenges to this industry e.g. food production in space, alternative production such as hydroponics or aquaponics - they can use the internet to find out what these are,
- Once they have selected their industry and challenge theme they begin to complete the other boxes answering the questions in the worksheet boxes -
- Finally, once they have completed the boxes e.g. they should devise a product, service or innovation for Space Exploration.

Using the example of fSpace ood and nutrition, this could be

  - What Are the possible challenges for the selected challenge theme, challenges could be no sun / water, long distances, dead seeds
  - Obstacles to developing solutions e.g. minimal space and trying to reduce weight for transportation
  - How would you overcome the obstacles e.g. vacuum packing or dehydration to reduce size and weight

MM4: L1TG SPACE VENTURE REMIX GRID

ACTIVITY 2 SPACE VENTURE REMIX GRID

Our service uses new technology to ensure the long life of seeds and transport them in space by vacuum packing and a unique seed dispersal system designed to be small and light yet durable, making it suitable for long-distance space exploration.

2. Once the learners have completed their boxes ask four random groups for input from the grid e.g. “Group one, tell me what’s written in your ‘Space Industry and Challenge theme’ box, group 2 tell me what’s written in your ‘Challenges’ , write their answer on the board. Repeat until all the boxes are filled.
3. Ask the groups to start coming up with possibilities for a business, activity or service that include the 4 variables, the more random the variables the better to push their creativity.

These emergent needs reflect the multifaceted challenges and opportunities associated with space exploration, highlighting the importance of interdisciplinary collaboration and innovation in addressing the complex requirements of future space missions.

You can use the table below to support them thinking about their challenges and obstacles as you circulate the room.

NEEDS	POSSIBLE ANSWERS
Food and Nutrition	• Development of sustainable food production systems for long-duration space missions. • Creation of nutrient-rich, shelf-stable foods that can withstand the rigors of space travel. • Exploration of alternative food sources such as hydroponics, aquaponics, and cellular agricul
Travel and Transportation	• Advancement of propulsion technologies for faster and more efficient interplanetary travel. • Development of reusable spacecraft and spaceplanes to reduce the cost of access to space. • Implementation of advanced life support systems to ensure the safety and well-being of crew members during extended space journeys.
Clothing and Personal Protective Equipment (PPE)	• Design of lightweight, durable, and protective space suits for astronauts working in harsh environments. • Development of smart textiles and materials with built-in sensors to monitor astronauts' health and performance. • Exploration of 3D printing technologies for on-demand production of clothing and PPE in space.

MM4: L1TG SPACE VENTURE REMIX GRID

NEEDS	POSSIBLE ANSWERS
Shelter and Habitats	• Design of modular habitats and inflatable structures for lunar and Martian colonies. • Integration of sustainable and self-sufficient systems for water recycling, air purification, and waste management. • Implementation of radiation shielding technologies to protect astronauts from cosmic radiation and solar flares
Data Services and Communication	• Establishment of high-speed, reliable communication networks for real-time data transmission between Earth and space. • Development of autonomous navigation systems for spacecraft and satellites to enable precise positioning and maneuvering. • Implementation of secure data storage and encryption protocols to protect sensitive information transmitted in space.
Healthcare and Medical Services	• Research into preventive healthcare measures and countermeasures to mitigate the effects of microgravity and space radiation on astronauts' health. • Exploration of telemedicine and remote diagnostics technologies for providing medical care to astronauts on long-duration space missions. • Development of pharmaceuticals and medical treatments tailored to the unique challenges of space travel, such as bone density loss and muscle atrophy.
Energy and Power Generation	• Advancement of renewable energy technologies such as solar panels and nuclear reactors for powering spacecraft and habitats. • Exploration of in-situ resource utilisation (ISRU) techniques for extracting and utilising resources such as solar energy, water, and regolith on planetary surfaces. • Development of energy storage systems for storing excess energy generated during periods of high solar activity or daylight.
Environmental Monitoring and Resource Management:	• Implementation of remote sensing technologies for monitoring planetary environments and assessing resource availability. • Integration of AI and machine learning algorithms for analysing environmental data and predicting potential hazards or anomalies. • Exploration of sustainable resource extraction and utilisation techniques to minimise the environmental impact of human activities in space.

MM4: L1TG SPACE EXPLORATION EXTENSION

Extension Activity

Lesson 1 Extension Activity: Use these questions to facilitate a discussion on the social, environmental, and economic implications of space exploration, along with positive and negative impacts:

Key Concerns / Issues: Generated from Emergent needs

Social Implications:

- Discussion Questions:
  - How does space exploration inspire and engage people around the world?
  - What are some potential benefits of space exploration for society, such as inspiring innovation, fostering international collaboration, and promoting STEM education?
  - How might space exploration contribute to addressing global challenges such as climate change, resource scarcity, and sustainable development?
  - What ethical considerations should be taken into account in space exploration, such as ensuring equitable access to space resources and protecting cultural heritage sites on other planets?
- Positive Impacts:
  - Inspiring future generations to pursue careers in science, technology, engineering, and mathematics (STEM).
  - Fostering international cooperation and diplomacy through collaborative space missions and partnerships.
  - Stimulating technological innovation and spin-off technologies that benefit society, such as GPS, medical imaging, and water purification systems.
- Negative Impacts:
  - Exacerbating existing social inequalities by diverting resources away from pressing societal needs such as poverty alleviation and healthcare.
  - Generating space debris and environmental pollution in Earth's orbit, posing risks to satellites and spacecraft.
  - Potentially leading to geopolitical tensions and competition over space resources, such as rare minerals and water ice.

Environmental Implications:

- Discussion Questions:
  - What are the environmental impacts of space exploration on Earth and beyond?
  - How does space debris affect the sustainability of space activities and the safety of spacecraft and satellites?
  - What are the potential risks and benefits of resource extraction and utilization on celestial bodies such as the moon and asteroids?
  - How can space exploration contribute to environmental monitoring and protection efforts on Earth, such as tracking climate change and natural disasters?

MM4: L1TG SPACE EXPLORATION EXTENSION

Extension Activity

- Positive Impacts:
  - Advancing our understanding of Earth's climate and environment through space-based observation and remote sensing technologies.
  - Facilitating the development of sustainable technologies and practices for resource utilisation in space, such as in-situ resource utilisation (ISRU).
  - Providing opportunities for environmental monitoring and protection efforts on Earth, such as tracking deforestation, pollution, and natural disasters.
- Negative Impacts:
  - Generating space debris and orbital debris that pose risks to operational spacecraft and satellites, as well as to future space missions.
  - Potentially disrupting ecosystems and geological formations on other celestial bodies through resource extraction and human activities.
  - Introducing contaminants and biological hazards to other planets and celestial bodies, potentially compromising scientific research and astrobiology studies.

Economic Implications:

- Discussion Questions:
  - How does space exploration contribute to economic growth and development on Earth?
  - What are the economic opportunities and challenges associated with commercial space activities such as satellite communication, space tourism, and asteroid mining?
  - How can space exploration stimulate innovation, entrepreneurship, and job creation in industries such as aerospace, technology, and manufacturing?
  - What are the potential economic risks and benefits of investing in space exploration compared to other priorities such as healthcare, education, and infrastructure?
- Positive Impacts:
  - Stimulating economic growth and investment in high-tech industries such as aerospace, telecommunications, and satellite imaging.
  - Creating new opportunities for job creation, entrepreneurship, and innovation in space-related sectors and downstream industries.
  - Generating revenue and economic value through commercial space activities such as satellite launches, space tourism, and space-based services.
- Negative Impacts:
  - Diverting resources and funding away from pressing societal needs such as healthcare, education, and poverty alleviation.
  - Exacerbating income inequality and social disparities by benefiting primarily wealthy individuals and corporations.
  - Potentially leading to economic instability and speculative bubbles in space-related industries, particularly in the absence of clear regulatory frameworks and oversight.

MM4: L1WS SPACE COMMERCIALISATION OVERVIEW

Activity 2 Overview of Space Commercialisation

INDUSTRY	DESCRIPTION
Satellite communications	
Launch services	
Satellite imaging	
Space-based manufacturing	
Space tourism	
Asteroid mining	
Space Food and Nutrition	
Space Tech: Travel and Transportation	
Space Clothing and Personal Protective Equipment (PPE)	
Space Shelter and Habitats	

MM4: L1WS MAPPING SPACE BASED GLOBAL CHALLENGES

INDUSTRY	DESCRIPTION
Space Technology - Data Services / Communication	
Space Healthcare / Medical Services	
Space Tech: Energy / Power Generation	
Space Tech: Environmental Monitoring and Resource Management	

ACTIVITY 2 SPACE VENTURE REMIX GRID - INSTRUCTIONS

Emergent (arising or developing) needs reflect the multifaceted challenges and opportunities associated with space exploration, highlighting the importance of interdisciplinary collaboration and innovation in addressing the complex requirements of future space missions.

Using the information from the table you completed for activity 1 you will complete the boxes in the worksheet Worksheet: Space Venture Remix Grid.

1. Select one of the industries from the table above - e.g. Space Food and Nutrition
2. Write your selection in the challenge box and think about what are the challenges to this industry e.g. food production in space, alternative production such as hydroponics or aquaponics - you can use the internet to find out what these are,
3. Once you have selected your industry and your challenge begin to complete the other boxes answering the questions in the worksheet boxes -
4. Finally, once you have completed your boxes - what is your product service or innovation for Space Exploration.

Using the example of fSpace ood and nutrition, this could be

- What Are the possible Challenges for the selected Space Challenge, challenges could be no sun / water, long distances, dead seeds
- Obstacles to the solutions - minimal space and trying to reduce weight for transportation
- How would you overcome the obstacles - vacuum packing or dehydrating to reduce size and weight

Our service uses new technology to ensure the long life of seeds and transport them in space by vacuum packing and a unique seed dispersal system designed to be small and light yet durable, making it suitable for long distance space exploration.

MM4: L1WSb Space Venture Remix Grid

Team Name _____

This worksheet will help you play with ideas for Space Ventures using your work from activity 2 Space Ventures Remix Grid

Fill in the boxes - we will then work with the whole group to develop a number of possible ideas.

WHAT IS YOUR SELECTED SPACE INDUSTRY AND CHALLENGE THEME

LIST THE POSSIBLE CHALLENGES FOR YOUR SELECTED SPACE THEME

OBSTACLES TO DEVELOPING SOLUTIONS TO THE CHALLENGE

HOW WOULD YOU OVERCOME THE OBSTACLES

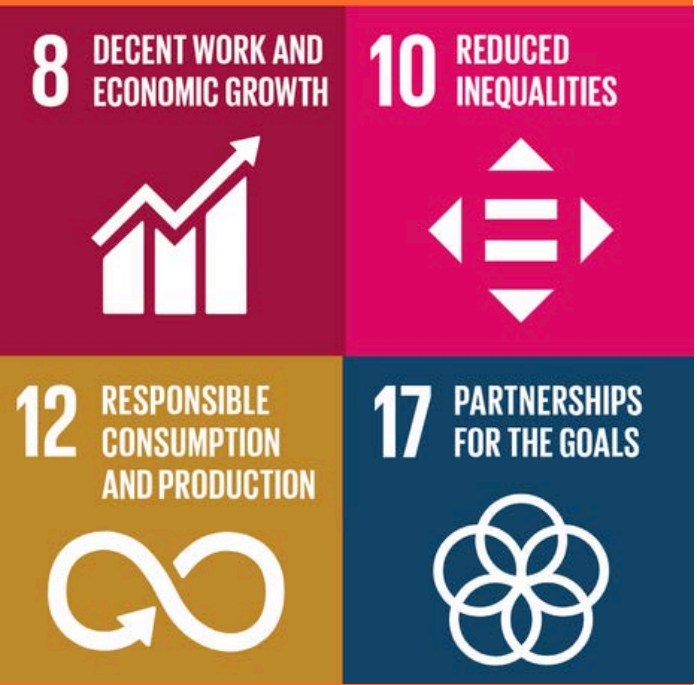
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 2 Developing a Space Venture Idea

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Developing A Space Venture Idea

In this lesson, learners continue their exploration of emergent needs and opportunities in space, by expanding on Lesson 1, activity 2's Space Venture remix.

This lesson enables students to develop an understanding of the process of generating ideas starting with the Space Venture Remix Grid and then using the remix method to develop their own Space Venture idea. This lesson supports learners in highlighting and understanding the importance of interdisciplinary collaboration and innovation in addressing the complex requirements of future space missions.

Vocabulary: Agility; Creativity; Disruptive Innovation; Emergent, Enterprise; Innovation, SWOT, Ventures

In this lesson, the learner will:

- continue to explore space and the emerging opportunities and implications for developing goods, services and innovation in space
- develop their own source of ideas and gain confidence using experimental approaches
- develop skills around idea generation using variables
- practice transferring and applying knowledge and skills
- will develop their creativity, innovation, and critical-thinking skills

Materials

- Worksheet: Space Venture Remix Grid
- Lesson 1 worksheets if completed
- Worksheet: Space Venture SWOT Analysis
- Teacher's Guide: Space Venture Remix
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L2 Developing a Space Venture Idea

Activity Instructions

Activity 1: Learner-driven Space Venture Remix Grid (30 mins)

1. If continuing from lesson 1, explain the activity – learners will use their worksheets from Lesson 1 to design a Space Venture
2. If not a continuation from Lesson 1 use the table in the Teachers Guide or the article in the media box 'The commercialisation of outer space' to support learners' understanding of the emerging Space Industry and to generate ideas.
3. Organise learners into small groups of 3, numbering each themselves 1 - 3 within the group, explaining that each person in the group should fill in a complete set of 4 boxes on their remix grid using a different space industry and challenge.
4. As in lesson 1, randomly ask 4 groups to contribute to the variable pool, out of which they will design their venture e.g. "Group [select a group] tell me what's written in the Space Industry / Challenge Theme (the first box) of person 2's worksheet and write their answer on the board.
5. Repeat three more times using random selection until you have something on the board for each of the worksheet boxes.
6. Ask learners to design a Space Venture from this group of variable pool.
7. Alternatively, in step 3 ask learners to pick a variable for each box from their worksheets to create the focus for their Space Venture and develop their ideas using that variable pool.

Activity 2 Undertaking a SWOT Analysis (20 min)

1. Explain the acronym SWOT and the role of a SWOT analysis
2. Model the activity using the collaborative 'variable pool' from the board with the Remix SWOT worksheet.
3. Ask the groups to undertake the same process using the worksheet: Space Venture SWOT Analysis, so they have a SWOT analysis on 3 Space Challenge themes that emerged from the first part of the lesson.
4. Depending on time, ask learners to reflect on the activities, is there anything that surprises them? How does the prospect of Space Exploration make them feel, excited, fearful or indifferent?

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L2 Developing a Space Venture Idea

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson: complete Activity 1 only

Extension: For a longer lesson: Learners can also visit Enterprise Ireland - media box to see if Irish companies are dealing with any of the space industry challenges in the woksheet: Space commercialisation overview .

Option B: Ask learners to generate 3 different Space Ventures, (product, service or innovation) ideas from the variable pool used in the class.

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Design Thinking Ideate [4:04 mins] https://www.youtube.com/watch?v=zbLxs6te5to

Space Foundation - Non Profit https://discoverspace.org/about/about-the-space-foundation/

Article: The commercialisation of outer space https://www.nortonrosefulbright.com/en/knowledge/publications/102a426e/the-commercialisation-of-outer-space#section3

Enterprise Ireland https://www.enterprise-ireland.com/en/supports/become-more-innovative/space-esa-homepage/esa-directory

Local Trip / Expertise / Additional Work and Assessments

Design Your Own Space Venture: Learners can use Activity 2, to design their own space venture, considering factors e.g. target market, mission objectives, technology requirements, and potential revenue streams - see Lesson 6 - 12 resources for support.

Use the questions from Lesson 1: Extension Activity in the Teacher's Guide to encourage them to consider the implications of their Space Venture to create a research project for the class - allocating the questions across small groups. Learners can present their findings using SDG 12 Future of Innovation and Enterprise, MM7: Media Communication module 1 - 4 https://www.muinincatalyst.com/innovation-media

For a larger project or assessment, use resources from the Problem to Pitch module - https://www.muinincatalyst.com/problem2pitch to support learners to develop their venture ideas and present them to the class.

MM4: L2TG SPACE VENTURE REMIX

ACTIVITY 1 SPACE VENTURE REMIX GRID

Instructions for Using the Worksheet: Space Venture Remix Grid

Explain the activity – learners will use generate the answers to the boxes using their completed worksheets from lesson 1 or you can project the table on the next two pages, by placing them on a slide.

1. Organise learners into groups of 3 and ask learners to complete the worksheet: Space Venture Remix Grid by brainstorming together so they can place an answer in each box

- Select one of the industries from the table they completed in activity e.g Space Food and Nutrition
- Write their selection in the Space Industry / Challenge theme box and think about what are the challenges to this industry e.g. food production in space, alternative production such as hydroponics or aquaponics - they can use the internet to find out what these are,
- Once they have selected their industry and challenge theme they begin to complete the other boxes answering the questions in the worksheet boxes -
- Finally, once they have completed the boxes e.g. they should devise a product, service or innovation for Space Exploration.

Using the example of Space Food and nutrition, this could be

  - What are the possible challenges for the selected Space Challenge theme, e.g. could be no sun / water for growth, long distances, dead seeds
  - Obstacles to developing the solutions - minimal space and trying to reduce weight for transportation
  - How would you overcome the obstacles - vacuum packing or dehydrating core substances to reduce size and weight

Possible Service: Our service uses new technology to ensure the long life of seeds and transport them in space by vacuum packing and a unique seed dispersal system designed to be small and light yet durable, making it suitable for long-distance space exploration.

2. Once the learners have completed their boxes ask four random groups for input from the grid e.g.

- Group one, person 3 tell me what's written in your 'Space Industry and Challenge theme' box, write their answer on the board.
- Group 2, person 1, give me an item that's listed in your 'Challenges list' box, write their answer on the board.
- Repeat until all the boxes are filled.

3. Ask the groups to start coming up with possibilities for a business, activity or service that include the 4 variables, the more random the variables the better to push their creativity.

MM4: L2TG SPACE VENTURE REMIX

Background: Table providing an overview of Space Commercialisation industries

INDUSTRY	SHORT DESCRIPTIONS
Satellite communications	The use of satellites to transmit data, voice, and video across long distances for global telecommunications networks.
Launch services	Companies that provide the technology and logistics to send spacecraft, satellites, and payloads into space
Satellite imaging	Capturing Earth's surface and space imagery through satellites for applications such as mapping, environmental monitoring, and security.
Space-based manufacturing	The production of goods and materials in microgravity environments, offering unique advantages like precision and efficiency.
Space tourism	Commercial space travel experiences for private individuals, allowing non-astronauts to visit space.
Asteroid mining	The extraction of valuable minerals and resources from asteroids for use on Earth or in space-based industries.
Space Food and Nutrition	The development and provision of sustainable, nutritious food systems to support human life in space environments
Space Tech: Travel and Transportation	Innovations in spacecraft and propulsion systems to enable human and cargo transport in space
Space Clothing and Personal Protective Equipment (PPE)	Specialised attire and protective gear designed to safeguard astronauts from the harsh conditions of space
Space Shelter and Habitats	Structures and habitats designed for sustaining human life during space exploration, whether on spacecraft, the Moon, or Mars

MM4: L2TG SPACE VENTURE REMIX AND EXTENSION

INDUSTRY	DESCRIPTION
Space Technology - Data Services / Communication	Advanced technologies for handling data transmission, storage, and communication between space and Earth.
Space Healthcare / Medical Services	The development of medical technologies, treatments, and protocols tailored to the unique health challenges faced by humans in space.
Space Tech: Energy / Power Generation	Technologies for generating and harnessing energy in space, such as solar power and nuclear energy for spacecraft and space colonies.
Space Tech: Environmental Monitoring and Resource Management	Technologies to monitor and manage environmental conditions and resources, both on Earth and in space, for sustainable exploration.

These emergent needs reflect the multifaceted challenges and opportunities associated with space exploration, highlighting the importance of interdisciplinary collaboration and innovation in addressing the complex requirements of future space missions.

NEEDS	POSSIBLE ANSWERS
Food and Nutrition	• Development of sustainable food production systems for long-duration space missions. • Creation of nutrient-rich, shelf-stable foods that can withstand the rigors of space travel. • Exploration of alternative food sources such as hydroponics, aquaponics, and cellular agricul
Travel and Transportation	• Advancement of propulsion technologies for faster and more efficient interplanetary travel. • Development of reusable spacecraft and spaceplanes to reduce the cost of access to space. • Implementation of advanced life support systems to ensure the safety and well-being of crew members during extended space journeys.
Clothing and Personal Protective Equipment (PPE)	• Design of lightweight, durable, and protective space suits for astronauts working in harsh environments. • Development of smart textiles and materials with built-in sensors to monitor astronauts' health and performance. • Exploration of 3D printing technologies for on-demand production of clothing and PPE in space.

MM4: L2TG SPACE VENTURE EXTENSION

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

NEEDS	POSSIBLE ANSWERS
Shelter and Habitats	• Design of modular habitats and inflatable structures for lunar and Martian colonies. • Integration of sustainable and self-sufficient systems for water recycling, air purification, and waste management. • Implementation of radiation shielding technologies to protect astronauts from cosmic radiation and solar flares
Data Services and Communication	• Establishment of high-speed, reliable communication networks for real-time data transmission between Earth and space. • Development of autonomous navigation systems for spacecraft and satellites to enable precise positioning and maneuvering. • Implementation of secure data storage and encryption protocols to protect sensitive information transmitted in space.
Healthcare and Medical Services	• Research into preventive healthcare measures and countermeasures to mitigate the effects of microgravity and space radiation on astronauts' health. • Exploration of telemedicine and remote diagnostics technologies for providing medical care to astronauts on long-duration space missions. • Development of pharmaceuticals and medical treatments tailored to the unique challenges of space travel, such as bone density loss and muscle atrophy.
Energy and Power Generation	• Advancement of renewable energy technologies such as solar panels and nuclear reactors for powering spacecraft and habitats. • Exploration of in-situ resource utilisation (ISRU) techniques for extracting and utilising resources such as solar energy, water, and regolith on planetary surfaces. • Development of energy storage systems for storing excess energy generated during periods of high solar activity or daylight.
Environmental Monitoring and Resource Management:	• Implementation of remote sensing technologies for monitoring planetary environments and assessing resource availability. • Integration of AI and machine learning algorithms for analysing environmental data and predicting potential hazards or anomalies. • Exploration of sustainable resource extraction and utilisation techniques to minimise the environmental impact of human activities in space.

MM4: L2TG SPACE VENTURE REMIX

Extension from Lesson 1

Extension Activity: Use these questions to facilitate further discussion on the social, environmental, and economic implications of space exploration, along with positive and negative impacts.

If learners Design their Space Venture as a larger project these questions and considerations can be used to support them.

Social Implications:

- Discussion Questions:
  - How does space exploration inspire and engage people around the world?
  - What are some potential benefits of space exploration for society, such as inspiring innovation, fostering international collaboration, and promoting STEM education?
  - How might space exploration contribute to addressing global challenges such as climate change, resource scarcity, and sustainable development?
  - What ethical considerations should be taken into account in space exploration, such as ensuring equitable access to space resources and protecting cultural heritage sites on other planets?
- Positive Impacts:
  - Inspiring future generations to pursue careers in science, technology, engineering, and mathematics (STEM).
  - Fostering international cooperation and diplomacy through collaborative space missions and partnerships.
  - Stimulating technological innovation and spin-off technologies that benefit society, such as GPS, medical imaging, and water purification systems.
- Negative Impacts:
  - Exacerbating existing social inequalities by diverting resources away from pressing societal needs such as poverty alleviation and healthcare.
  - Generating space debris and environmental pollution in Earth's orbit, posing risks to satellites and spacecraft.
  - Potentially leading to geopolitical tensions and competition over space resources, such as rare minerals and water ice.

Environmental Implications:

- Discussion Questions:
  - What are the environmental impacts of space exploration on Earth and beyond?
  - How does space debris affect the sustainability of space activities and the safety of spacecraft and satellites?
  - What are the potential risks and benefits of resource extraction and utilization on celestial bodies such as the moon and asteroids?
  - How can space exploration contribute to environmental monitoring and protection efforts on Earth, such as tracking climate change and natural disasters?

MM4: L2TG SPACE VENTURE REMIX

Extension Activity

- Positive Impacts:
  - Advancing our understanding of Earth's climate and environment through space-based observation and remote sensing technologies.
  - Facilitating the development of sustainable technologies and practices for resource utilisation in space, such as in-situ resource utilisation (ISRU).
  - Providing opportunities for environmental monitoring and protection efforts on Earth, such as tracking deforestation, pollution, and natural disasters.
- Negative Impacts:
  - Generating space debris and orbital debris that pose risks to operational spacecraft and satellites, as well as to future space missions.
  - Potentially disrupting ecosystems and geological formations on other celestial bodies through resource extraction and human activities.
  - Introducing contaminants and biological hazards to other planets and celestial bodies, potentially compromising scientific research and astrobiology studies.

Economic Implications:

- Discussion Questions:
  - How does space exploration contribute to economic growth and development on Earth?
  - What are the economic opportunities and challenges associated with commercial space activities such as satellite communication, space tourism, and asteroid mining?
  - How can space exploration stimulate innovation, entrepreneurship, and job creation in industries such as aerospace, technology, and manufacturing?
  - What are the potential economic risks and benefits of investing in space exploration compared to other priorities such as healthcare, education, and infrastructure?
- Positive Impacts:
  - Stimulating economic growth and investment in high-tech industries such as aerospace, telecommunications, and satellite imaging.
  - Creating new opportunities for job creation, entrepreneurship, and innovation in space-related sectors and downstream industries.
  - Generating revenue and economic value through commercial space activities such as satellite launches, space tourism, and space-based services.
- Negative Impacts:
  - Diverting resources and funding away from pressing societal needs such as healthcare, education, and poverty alleviation.
  - Exacerbating income inequality and social disparities by benefiting primarily wealthy individuals and corporations.
  - Potentially leading to economic instability and speculative bubbles in space-related industries, particularly in the absence of clear regulatory frameworks and oversight.

L2WS SPACE VENTURE REMIX GRID

Team Name _____

This worksheet will help you play with ideas for Space Ventures using your work from activity 2 Space Ventures Remix Grid

Fill in the boxes - we will then work with the whole group to develop a number of possible ideas.

WHAT IS YOUR SELECTED SPACE INDUSTRY AND CHALLENGE THEME

LIST THE POSSIBLE CHALLENGES IN FOR YOUR SELECTED SPACE THEME

OBSTACLES TO DEVELOPING SOLUTIONS TO THE CHALLENGE

HOW WOULD YOU OVERCOME THE OBSTACLES

L2WSB SPACE VENTURE SWOT ANALYSIS

Name _____

Date _____

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Use this adapted SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis to consider each of your group's Space Venture ideas.

Take one idea from each of the group members and work together to complete the boxes for each Space Venture

VENTURE PURPOSE	STRENGTHS	WEAKNESSES	USERS / CLIENTS OPPS AND THREATS

VENTURE PURPOSE	STRENGTHS	WEAKNESSES	USERS / CLIENTS OPPS AND THREATS

VENTURE PURPOSE	STRENGTHS	WEAKNESSES	USERS / CLIENTS OPPS AND THREATS

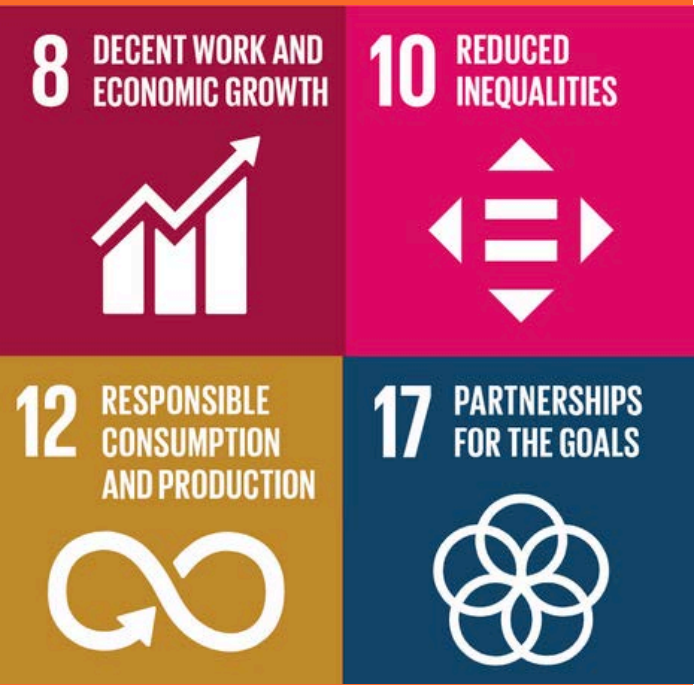
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 3 Exploring Space Entrepreneurship

Subject Areas: CSPE / SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Exploring Space Entrepreneurship

IIn this lesson, learners will explore the entrepreneurial aspects of commercialising space, including identifying opportunities, overcoming challenges, considering the implications and developing innovative business solutions.

The lesson builds the foundation for a deeper understanding of the entrepreneurial aspects of commercialising space and inspires learners to explore career opportunities in space entrepreneurship.

The lesson will support learners to see the significance of entrepreneurship in driving innovation, investment, and economic growth in the space industry, including the role of startups and private ventures in advancing space exploration.

Vocabulary: Business Models, Competitive Advantage, Market Demand, Open Source Space, Space Entrepreneurship, Start-ups

In this lesson, the learner will:

- continue to explore space and the emerging opportunities and implications for developing goods, services and innovation in space
- develop their own source of ideas and gain confidence using experimental approaches
- develop skills around idea generation using variables
- practice transferring and applying knowledge and skills
- will develop their creativity, innovation, and critical-thinking skills

Materials

- Worksheet: What is Space Entrepreneurship?
- Teacher's Guide: What is Space Entrepreneurship?
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L3 Exploring Space Entrepreneurship

Activity Instructions

Activity 1: What is Space Entrepreneurship? (25 mins)

1. In pairs, ask learners to complete part 1, Worksheet: What is Space Entrepreneurship?, defining key terms in their own words.
2. Learners will have to divide up the tasks to ensure they finish the activity in the time allocated
3. Ask learners to type their definitions into a shared document in the e-classroom e.g. Microsoft Teams or Google Drive or shared space to develop a 'hive mind' glossary.

Activity 2 Activity 2 What is Space Entrepreneurship? - Key Players (25 mins)

1. Ask learners to complete part 2, Worksheet: What is Space Entrepreneurship? - Key Players section - by researching two of five key entrepreneurial ventures.
2. Working in pairs, learners will select one of the companies/entrepreneurs each to research.
3. Ask learners to share the goals, achievements, and business strategies of two of these companies, to consider their role in disrupting the traditional space industry through innovation and enterprise.
4. Once learners have completed their research, they read should read each other's findings and discuss at least 2-3 of the following questions. This can also be done as a whole class activity.

    - What are the potential benefits and risks of private companies leading the future of space exploration compared to government agencies?
    - How do you think space exploration will impact life on Earth in terms of technology, economy, and society?
    - What ethical or environmental concerns arise from the commercialisation of space, and how should these companies address them?
    - How do you think space tourism and the accessibility of space travel will change human perspectives on space and our planet?
    - In your opinion, what should be the top priority for space exploration—scientific discovery, business opportunities, or human settlement? Why?

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L3 Exploring Space Entrepreneurship

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete Activity 1 only. Use any remaining time to summarise their learning and check their understanding or explore the case studies as preparation for the following lesson.

Option B: Complete Activity 1, and facilitate a brief discussion on what they have found out about the role of entrepreneurship in driving innovation and growth in the space industry.

Extension: For a longer lesson: Ask learners to share their insights related to their research on Space entrepreneurship. See Teacher's Guide for examples of deeper discussion questions.

Option B: Use their insights to initiate a discussion on the opportunities and challenges faced by space entrepreneurs, such as securing funding, navigating regulatory frameworks, and developing innovative technologies. See Teacher's Guide for examples of key prompt / discussion questions.

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Case Studies:

- Space X - Elon Musk https://www.spacex.com/
- Rocket Lab USA https://www.rocketlabusa.com/
- Virgin Galaxy / Richard Branson https://www.virgingalactic.com/
- Blue Origin - Jeff Bezos (Amazon) https://www.blueorigin.com/
- ConsenSYS Space (open source space) https://www.consensys.space/

Enterprise Ireland Company Directory https://www.enterprise-ireland.com/en/supports/become-more-innovative/space-esa-homepage/esa-directory

Local Trip / Expertise / Additional Work and Assessments

Invite a speaker from a company on the Enterprise Ireland Space Directory for a class zoom

Learners can explore Enterprise Ireland's Space Directory to select an Irish Space entrepreneurial company and consider their innovations, goals innovations and achievements and business strategies. This could be extended to a case study see supporting resources in MM2, Lesson 1. Learners can also assess the impacts positively and negatively of the businesses using the discussion questions in Lesson 1 from this module and present their findings using SDG 12 Future of Innovation and Enterprise, MM7: Media Communication module 1 - 4 https://www.muinincatalyst.com/innovation-media

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MM4: L3TG WHAT IS SPACE ENTREPRENEURSHIP?

Activity 1 Concise Definitions of the Key Terms

KEY TERM	SHORT DESCRIPTIONS
Business Model	Frameworks that define how a company creates, delivers, and captures value, outlining its revenue streams and operational strategies.
Competitive Advantage	A unique edge that allows a business to outperform its competitors, often through cost efficiency, innovation, or differentiation.
Disruption	A significant change in an industry or market caused by innovative technologies or business models that challenge established norms and competitors.
Market Demand	The total quantity of a product or service that consumers are willing and able to buy at a given price over a certain period.
Open Source Space	Collaborative, publicly accessible space projects or technologies, where designs and data are shared openly for innovation and development.
Space Entrepreneurship	The pursuit of business opportunities in space-related industries, including innovation in satellite technology, space travel, and space-based services.
Space Exploration	The investigation and discovery of outer space through the use of astronomy, spacecraft, and technologies, with the goal of advancing scientific knowledge and understanding of the universe beyond Earth.
Space Innovation	The development of new technologies, processes, or solutions that advance the exploration, commercialization, or utilization of space.
Space Law and Regulation	Rules and laws governing industry practices, safety standards, and compliance, especially critical in space exploration and commercial activities.
Start-ups	Newly established companies, often focused on innovation and rapid growth, seeking to disrupt existing markets or create new ones.

MM4: L3TG WHAT IS SPACE ENTREPRENEURSHIP?

Activity 2 Case Study Achievements and Innovations / Disruptions

These companies have each disrupted the space industry in unique ways, from lowering costs and increasing access to space to introducing entirely new markets like space tourism and open-source space exploration.

SPACEX – ELON MUSK

- Reusable Rockets: SpaceX pioneered reusable rocket technology with the Falcon 9, dramatically lowering the cost of launching payloads into space.
- Private Human Spaceflight: SpaceX became the first private company to send astronauts to the International Space Station (ISS) with its Crew Dragon spacecraft.
- Starship Development: SpaceX is developing Starship, a fully reusable spacecraft designed for missions to the Moon, Mars, and beyond, aiming to make interplanetary travel feasible.
- Starlink Satellite Network: SpaceX launched the Starlink project, deploying a constellation of satellites to provide global high-speed internet access, especially in underserved regions.
- Disruption: SpaceX's innovations have pushed the space industry toward greater efficiency and commercial viability, challenging traditional government space agencies and competitors.

ROCKET LAB USA

- Small Satellite Launch Services: Rocket Lab developed the Electron rocket, specifically designed for small satellite payloads, making space access affordable and frequent for smaller missions.
- Reusability: Rocket Lab is advancing rocket reusability with plans to recover and reuse Electron's first stage, similar to SpaceX, but on a smaller scale.
- Photon Satellite Platform: Rocket Lab introduced Photon, a customisable satellite platform that enables businesses to send payloads to space without needing their own satellite infrastructure.
- Rapid, Frequent Launches: Rocket Lab offers a high cadence of launches with smaller, more flexible payloads, disrupting the industry by democratising access to space for startups and research institutions.
- Disruption: By focusing on small, cost-effective launches, Rocket Lab has opened space to more players and industries, making space missions more accessible.

RICHARD BRANSON / VIRGIN GALACTIC

- Space Tourism Pioneer: Virgin Galactic was the first company to focus on making space travel accessible to private individuals, launching the commercial space tourism industry.
- Suborbital Flights: Virgin Galactic’s SpaceShipTwo was designed to carry passengers on suborbital spaceflights, offering the experience of weightlessness and viewing Earth from space.
- Commercial Spaceport: Virgin Galactic built the world's first purpose-built commercial spaceport, Spaceport America, to support regular space tourism flights.

- Sustainable Space Travel: The company is focused on making space travel environmentally sustainable, with goals to minimise the environmental impact of suborbital flights.
- Disruption: Virgin Galactic disrupted the traditional perception of space exploration by positioning space as a potential consumer experience, expanding the space economy into the tourism sector.

CONSENSYS SPACE (OPEN SOURCE SPACE)

- Open-Source Space Technology: ConsenSYS Space promotes the use of open-source platforms for space exploration, offering public access to tools and data to foster global collaboration.
- Space Data Marketplace: They developed TruSat, a decentralised, community-driven system to track satellites, helping increase transparency and access to satellite data.
- Democratising Space Access: By advocating for open-source projects, ConsenSYS Space seeks to make space technology accessible to non-governmental players, including private individuals and small organisations.
- Blockchain in Space: They integrate blockchain technology to create decentralised systems for space data sharing and collaboration, enabling trust and transparency in space operations.
- Disruption: ConsenSYS Space challenges traditional space ownership and control by opening space exploration and data access to a wider audience, beyond corporations and governments.

BLUE ORIGIN – JEFF BEZOS

- Reusable Rocket Technology: Blue Origin developed the New Shepard rocket, capable of vertical takeoff and landing, with a focus on reusability, similar to SpaceX's model.
- Commercial Space Travel: The company is working on suborbital space tourism, offering commercial flights for private individuals aboard New Shepard.
- New Glenn: Blue Origin is developing New Glenn, a heavy-lift orbital rocket designed to rival SpaceX's Falcon Heavy, aimed at launching large payloads into space.
- Vision for Space Habitats: Blue Origin's long-term vision includes enabling millions of people to live and work in space, with plans for space habitats and colonies.
- Disruption: Blue Origin has challenged existing space companies by combining reusability, a long-term vision for space colonisation, and a focus on space tourism, contributing to the commercial shift in the space industry.

Activity 2 Case Study Discussion Questions

SpaceX – Elon Musk

- How has SpaceX changed the space industry with its reusable rocket technology, and what do you think this means for the future of space exploration?

MM4: L3TG WHAT IS SPACE ENTREPRENEURSHIP?

- What role does private industry play in space exploration today compared to government agencies like NASA?
- What are some challenges SpaceX might face in making space travel accessible to the public, and how could they overcome them?
- SpaceX plans to colonise Mars. What are the potential benefits and risks of this plan for humanity?
- Do you think space exploration should prioritise technological innovation or focus on environmental and ethical concerns? Why?

Rocket Lab USA

- What makes Rocket Lab's small satellite launch services unique in the space industry, and how does it compare to larger companies like SpaceX?
- Why do you think small satellites and cheaper launch services are important for science, business, and global communications?
- Rocket Lab focuses on frequent, lower-cost launches. How do you think this could impact industries beyond space exploration?
- How could Rocket Lab’s Electron rocket, designed for smaller payloads, contribute to global access to space?
- What role do you think smaller companies like Rocket Lab play in the global space race compared to giants like SpaceX or Blue Origin?

Richard Branson / Virgin Galactic

- Virgin Galactic aims to bring space tourism to the public. What are the potential benefits and drawbacks of making space travel a luxury experience?
- Do you think space tourism should be a priority for the space industry, or should efforts focus more on exploration and scientific research? Why?
- What are the environmental impacts of space tourism, and how could companies like Virgin Galactic reduce them?
- How could commercial space tourism shape the future of human presence in space, and what societal changes might come from it?
- If given the opportunity, would you want to travel to space as a tourist? Why or why not?

ConsenSYS Space (Open Source Space)

- How does the idea of open-source space exploration differ from traditional space exploration approaches by companies like SpaceX or NASA?
- What are the benefits and potential risks of making space technology and data openly accessible to the public?
- How could open-source collaboration, like ConsenSYS Space, help democratise space exploration and make it accessible to more people and countries?
- Do you think open-source space projects will speed up or slow down space innovation? Why?

ConsenSYS Space (Open Source Space)

5. How could open-source space technologies contribute to solving global challenges on Earth, like climate change or internet access?

Blue Origin – Jeff Bezos

1. How does Blue Origin's vision of building space habitats and creating a space-based economy compare with other companies' goals, such as SpaceX's colonisation of Mars?
2. Do you think Jeff Bezos' focus on space tourism and developing a space economy is realistic or too ambitious? Why?
3. How can companies like Blue Origin ensure the long-term sustainability of space resources and prevent exploitation?
4. What challenges do you think Blue Origin will face in achieving its goal of making space travel more affordable and accessible?
5. Blue Origin envisions millions of people living and working in space. What impact could this have on Earth's society, economy, and environment?

This activity can also be supported with resources from Lesson 1, extension activity - impact.

Extension Activity

Lesson 1 Extension Activity: Use these questions to facilitate a discussion on the opportunities and challenges faced by space entrepreneurs, fostering critical thinking and deeper understanding among learners. These questions can also be set as a research activity focused on Ireland.

Securing Funding:

- What are some common sources of funding for space entrepreneurship ventures?
- How do space entrepreneurs attract investors and secure funding for their projects?
- What are the main challenges space entrepreneurs face when seeking funding, and how can they overcome these challenges?

Navigating Regulatory Frameworks:

- What are some of the regulatory bodies and frameworks that govern space activities?
- How do space entrepreneurs navigate regulatory hurdles and ensure compliance with international and national space laws?
- What are some potential risks and consequences of non-compliance with space regulations, and how can space entrepreneurs mitigate these risks?

Developing Innovative Technologies:

- What role does innovation play in the success of space entrepreneurship ventures?
- What are some examples of innovative technologies developed by space entrepreneurs, and how have these technologies transformed the space industry?

MM4: L3TG WHAT IS SPACE ENTREPRENEURSHIP?

- What are the main challenges space entrepreneurs face in developing and implementing innovative technologies, and how can they address these challenges?

Market Demand and Competition:

- What factors influence market demand for space-based products and services?
- How do space entrepreneurs identify and assess market opportunities in the space industry?
- What are some strategies space entrepreneurs use to differentiate their offerings and stay competitive in the market?

International Collaboration and Partnerships:

- How important is international collaboration in the success of space entrepreneurship ventures?
- What are some examples of successful partnerships between space entrepreneurs and international space agencies or organisations?
- What are the benefits and challenges of collaborating with international partners, and how can space entrepreneurs maximise the benefits while mitigating the challenges?

MM4: L3WS WHAT IS SPACE ENTREPRENEURSHIP?

Activity 1 Concise Definitions of the Key Terms

KEY TERM	SHORT DESCRIPTIONS
Business Model	
Competitive Advantage	
Disruption	
Market Demand	
Open Source Space	
Space Entrepreneurship	
Space Exploration	
Space Innovation	
Space Law and Regulation	
Start-ups	

MM4: L3WS WHAT IS SPACE ENTREPRENEURSHIP?

Activity 2 What is Space Entrepreneurship? - Key Players

1. Working in pairs, select one of the companies/entrepreneurs each below to research.
2. Look at the goals/achievements of the companies and how they disrupted the Space Industry through innovation and enterprise. Once you have completed your research, read each other's findings and discuss using the following questions

    - What are the potential benefits and risks of private companies leading the future of space exploration compared to government agencies?
    - How do you think space exploration will impact life on Earth in terms of technology, economy, and society?
    - What ethical or environmental concerns arise from the commercialization of space, and how should these companies address them?
    - How do you think space tourism and the accessibility of space travel will change human perspectives on space and our planet?
    - In your opinion, what should be the top priority for space exploration—scientific discovery, business opportunities, or human settlement? Why?

CASE STUDY	DETAILS	INNOVATION / DISRUPTION
Space X - Elon Musk https://www.spacex.com/		
Richard Branson / Virgin Galaxy https://www.virgingalactic.com/		

MM4: L3WS WHAT IS SPACE ENTREPRENEURSHIP?

CASE STUDY	DETAILS	INNOVATION / INSPIRATION
Rocket Lab USA https://www.rocketlabusa.com/		
ConsenSYS Space (open source space) https://www.consensys.space/		
Blue Origin / Jeff Bezos https://www.blueorigin.com/		

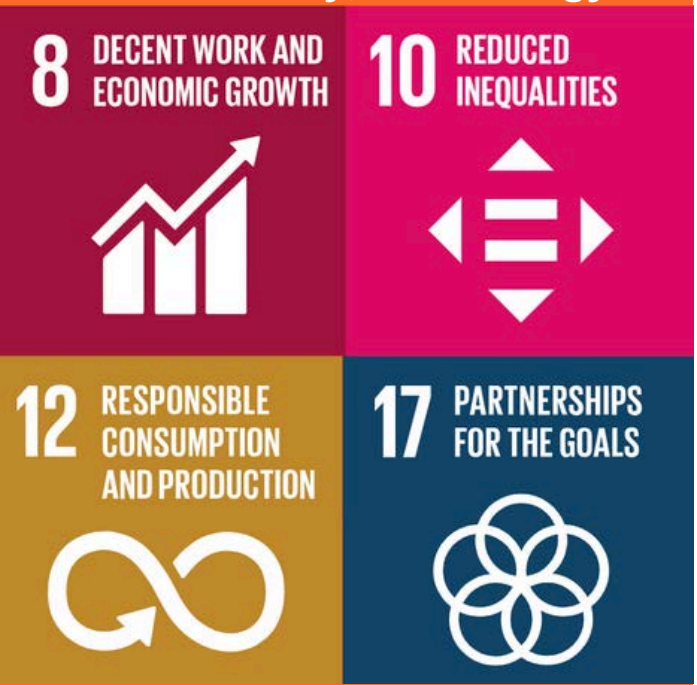
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 4 Exploring Inclusion in the Space Industry 1

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Exploring Inclusion in the Space Industry 1

In these three, linked lessons, learners will consider the importance of diversity and inclusion in space entrepreneurship, with a focus on the participation of women, indigenous communities, people of colour, and differently-abled individuals.

By recognising and celebrating diverse perspectives and contributions, a more equitable and innovative future for space exploration and beyond, can be created. By understanding the value of representation and equity, learners will be equipped to advocate for a more inclusive space economy.

Lesson 4, focuses on showcasing women highlighting challenges and opportunities of promoting inclusive practices in space-related industries, identifying the barriers that marginalised groups face and considering ways to overcome them.

Vocabulary: Differently-abled, Diversity, Equity, Inclusion, Indigenous, Representation

In this lesson, the learner will:

- understand the role of women in the space industry
- Identify opportunities and challenges in promoting inclusion in the space industry
- consider the social and ethical implications of lack of diversity in the space industry
- critically consider the need to promote inclusion and diversity in future space industries

Materials

- Worksheet: Female Space Professionals
- Worksheet: Planning Your Poster
- Teacher's Guide: Female Space Professionals
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L4 Exploring Inclusion in the Space Industry 1

Activity Instructions

Activity 1: Female Space Professionals - a showcase (25 mins)

1. Working in groups of four, assign learners one of the female space professionals from the Teacher's Guide: Female Space Professionals to research as the focus of their showcase.
2. Ask learners to gather the following information for their assigned professional

    - Background:
    - Space Sector / Profession:
    - Contributions to the Space Industry:
    - Anecdotes / Facts:

3. Remind learners to divide the task between the group, with each member responsible for one of the research points the Worksheet: Female Space Professionals completed on time.

Activity 2: Create a Showcase Poster (25 mins)

1. Continuing to work in their groups, learners will organise their information on their assigned professional to create a showcase poster.
2. Using the Worksheet: Planning Your Poster, learners will plan their poster's layout and design to enable them to create a clear, engaging showcase poster that effectively communicates the space explorer's achievements and story
3. Once their planning is complete ask learners to log into Canva or access a lesson you have set up previously in Canva www.canva.com/education - see module overview for set up details.
4. Select a template using their planning ideas and assign each member of the group to take one of the bullets below

    - A brief biography of the space professional, highlighting key milestones and achievements.
    - Images/photographs depicting the space explorer in action or participating in space missions.
    - Quotes or inspirational messages from the space explorer.
    - Optional: Fun facts or trivia about the space explorer's life and career

5. Circulate encouraging groups to develop their template using the worksheet guidelines

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L4 Exploring Inclusion in the Space Industry 1

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete the planning for the showcase poster and complete poster in a follow-up class.

Extension: For a longer lesson, summarise the key takeaways from the discussion and ask learners to share their thoughts and ideas for fostering a more inclusive space industry. See the Teacher's Guide for a list of questions and links used to extend the discussion

Option B: In the follow-up class, use any remaining time to explore challenges faced by women in the space industry, such as gender bias, lack of representation, and and barriers to advancement

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Getting involved in the Space Industry as a young woman - Accessing Space' [1:58 mins]
https://youtu.be/P1PHJOOdmf8?feature=shared

Why we need more women in the space sector
https://www.skyatnightmagazine.com/space-missions/need-more-women-in-space-sector

Women in the New Space - Recruitment Insights
https://www.evona.com/blog/women-in-the-new-space-sector/#:~:text=Whilst%20it's%20true%20that%20the,SpaceX%3B%20and%20Ellen%20Stofan%2C%20the

Youtube playlist - Inclusion in Space seven videos from different perspectives on inclusion in space
https://www.youtube.com/playlist?list=PLjvl2quYK9xz3s9MDPmAHyHtdMmQV2iId

Local Trip / Expertise / Additional Work and Assessments

IInclusive Space Explorer Showcase: Learners can create a presentation / exhibition in school or online showcasing the significant contributions to space exploration, breaking barriers and inspiring future generations of scientists, engineers, and explorers that diverse individuals have made. Each group can undertake presenting their showcases to others in the class or in the school, or create short introductory videos, for an online showcase

Ask learners to research initiatives that key players (can use the key players from MM4: Lesson 2 as well as agencies e.g. NASA, ESA) in the Space Industry are doing or could do to support diversity and inclusion within the sector.

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MM4: 4TG FEMALE SPACE PROFESSIONALS

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

List of Women in Space - A Showcase

These individuals have made significant contributions to space exploration, breaking barriers and inspiring future generations of scientists, engineers, and explorers. Assign one space professional to each group in the class

1. Valentina Tereshkova: First woman to fly in space, aboard the Vostok 6 spacecraft in 1963, becoming the first and youngest woman to travel to space.
2. Sally Ride: First American woman in space, flying aboard the Space Shuttle Challenger in 1983. She later founded Sally Ride Science, an organization dedicated to inspiring young people, especially girls, to pursue STEM education.
3. Eileen Collins: First female Space Shuttle pilot and first female Space Shuttle commander, piloting the Space Shuttle Discovery in 1995 and commanding both the Discovery and Atlantis shuttles on subsequent missions.
4. Peggy Whitson: Record-setting astronaut who has spent the most time in space by any American astronaut, male or female, with a total of 665 days across three missions. She also served as the first female commander of the International Space Station (ISS).
5. Kathryn D. Sullivan: First American woman to walk in space, completing a spacewalk aboard the Space Shuttle Challenger in 1984. She later served as the Administrator of the National Oceanic and Atmospheric Administration (NOAA).
6. Christina Koch: NASA astronaut who set the record for the longest single spaceflight by a woman, spending 328 days aboard the International Space Station (ISS) from 2019 to 2020.
7. Nicole Stott: NASA astronaut and aquanaut who has completed two spaceflights and participated in a NASA mission to the Aquarius underwater laboratory. She is also an artist and advocate for STEAM education.
8. Kellie Gerardi is an American social media influencer, popular science communicator, and citizen astronaut who is known for a sub-orbital spaceflight with Virgin Galactic as a payload specialist in 2023. She was among the first 100 women in space and was also a candidate for the Mars One mission. She is scheduled to lead an all-female sub-orbital spaceflight with Virgin Galactic in 2026.
9. Dr Norah Patten is an Irish aeronautical engineer and an award-winning STEM (Science, Technology, Engineering and Maths) advocate from Ballina, County Mayo. Dr Patten was selected to become Ireland’s first person in space as part of a mission on board Virgin Galactic's second generation of spacecraft, known as Delta in 2026/2027.
10. Dr Shawna Pandya is a physician, aquanaut, scientist-astronaut candidate program graduate with the International Institute for Astronautical Sciences (IIAS), skydiver, pilot-in-training, VP of Immersive Medicine with Luxsonic Technologies, Director of Medical Research at Orbital Assembly Corporation and Fellow of the Explorers Club. She is Director of IIAS’ Space Medicine Group and Chief Instructor for IIAS’ Operational Space Medicine course. Dr. Pandya was on the first crew to test a commercial spacesuit in zero-gravity in 2015 and part of the all women Virgin Galactic Delta mission in 2026/2027.

MM4: 4WS FEMALE SPACE PROFESSIONAL

Assigned Space Explorer:

Background:

Space Sector / Profession:

Contributions to the Space Industry:

Anecdotes / Facts:

Create a showcase Poster: Each member of the group should take one of the bullets below and include the following points on your poster.

- **A brief biography of the space explorer, highlighting key milestones and achievements.**

- **Images or photographs depicting the space explorer in action or participating in space missions.**
    - Make sure you have permission to use the image (s)you have selected
    - Download and save your images to your online learner folder space - by right-clicking the image, select save as image, naming it clearly and save

- **Quotes or inspirational messages from the space explorer.**

- **Optional: Fun facts or trivia about the space explorer's life and career**

MM4: 4WSB PLANNING YOUR POSTER

Points to consider when planning you showcase poster and choosing a template:

1. Choosing a Layout/Template:

- Balance between text and visuals: Select a template that offers space for both written content (biography, quotes) and visuals (images, photographs). Ensure it's easy to read and visually appealing.
- Sections: Choose a design that allows you to organise content into clear sections (e.g., "Biography," "Key Milestones," "Quotes," "Fun Facts") so the viewer can navigate the poster easily.
- Image placement: Choose a template with designated spaces for images, ideally near or alongside the text they relate to (e.g., images of space missions next to key milestones).

2. Biography Section:

- Brief, impactful biography: Ensure the biography section is concise with key life milestones (e.g., education, career beginnings, major space missions). Highlight significant achievements such as space missions, leadership roles, or contributions to space science.
- Text formatting: Use bullet points or short paragraphs to keep it clear and readable. Avoid long blocks of text.

3. Images or Photographs:

- Choose high-quality images: Use clear, high-res. images of the space explorer, showing them in action (e.g., during space missions, training, or key moments in their career).
- Captions: Add short captions to the images to explain what's happening or the significance of the moment.

4. Quotes or Inspirational Messages:

- Highlight with design: Use a distinct font or colour for quotes to make them stand out. Place them in visually prominent spots on the poster, like near the top or in the middle, where they'll catch attention.
- Relevance: Select quotes that reflect the space explorer's philosophy, motivation, or views on space exploration and science.

5. Fun Facts or Trivia (Optional):

- Placement: Set aside a small section for "Fun Facts" that's separate from the main biography. This could be at the bottom or in the side margins for easy visibility.
- Engage your audience: Include interesting, lesser-known facts (e.g., personal hobbies, unique experiences in space, or unexpected career paths) to make the space explorer more relatable.

6. Design and Visual Appeal:

- Color scheme: Consider Choosing colours that align with the space theme (e.g., dark blues, blacks, and silvers) and that also make the text and images stand out.
- Typography: Ensure the font size is large enough for easy reading, with headings and key information in bold or larger fonts.

7. Conclusion / Call to Action (Optional):

Closing thought: Include a final section summarising the impact and contributions or encouraging others to explore careers in space.

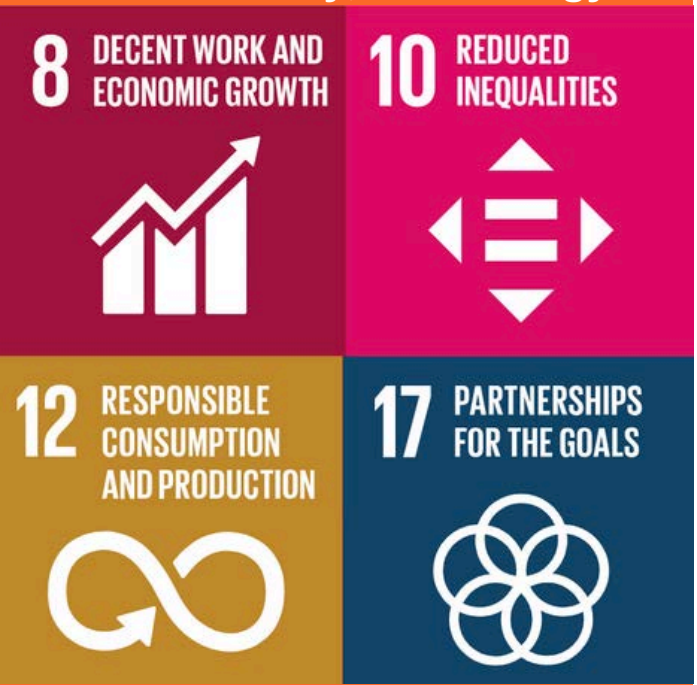
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 5 Exploring Inclusion in the Space Industry 2

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Exploring Inclusion in the Space Industry 2

In these three, linked lessons, learners will consider the importance of diversity and inclusion in space entrepreneurship, with a focus on the participation of women, indigenous communities, people of colour, and differently-abled individuals.

By recognising and celebrating diverse perspectives and contributions, a more equitable and innovative future for space exploration and beyond, can be created. By understanding the value of representation and equity, learners will be equipped to advocate for a more inclusive space economy.

Lesson 5, focuses on showcasing Indigenous Professionals and People of Colour highlighting challenges and opportunities of promoting inclusive practices in space-related industries, identifying the barriers that marginalised groups face and considering ways to overcome them.

Vocabulary: Differently-abled, Diversity, Equity, Inclusion, Indigenous, Representation

In this lesson, the learner will:

- understand the role of indigenous and people of colour professionals in the space industry
- Identify opportunities and challenges in promoting inclusion in the space industry
- consider the social and ethical implications of lack of diversity in the space industry
- critically consider the need to promote inclusion and diversity in future space industries

Materials

- Worksheet: Indigenous and People of Colour Space Professionals
- Worksheet: Planning Your Poster
- Teacher's Guide: Indigenous and People of Colour Space Professionals
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L5 Exploring Inclusion in the Space Industry 2

Activity Instructions

Activity 1: Indigenous and People of Colour Space Professionals - a showcase (25 mins)

1. Working in groups of four, assign learners one of the Space Professionals from the Teacher's Guide: Indigenous and People of Colour Space Professionals to research as the focus of their showcase.
2. Ask learners to gather the following information for their assigned professional
    - Background:
    - Space Sector / Profession:
    - Contributions to the Space Industry:
    - Anecdotes / Facts:
3. Remind learners to divide the task equally, with each member responsible for one of the research points and the worksheet is completed on time.

Activity 2: Create a Showcase Poster (25 mins)

1. Continuing to work in their groups, learners will organise their information on their assigned professional to create a showcase poster.
2. Using the Worksheet: Planning Your Poster, learners will plan their poster's layout and design to enable them to create a clear, engaging showcase poster that effectively communicates the space explorer's achievements and story
3. Once their planning is complete ask learners to log into Canva or access a lesson you have set up previously in Canva www.canva.com/education - see module overview for set up details.
4. Ask learners to select a template that reflects their planning and assign each member of the group to take one of the bullets below
    - A brief biography of the space professional, highlighting key milestones and achievements.
    - Images/photographs depicting the space explorer in action or participating in space missions.
    - Quotes or inspirational messages from the space explorer.
    - Optional: Fun facts or trivia about the space explorer's life and career
5. Circulate encouraging groups to develop their template using the worksheet guidelines

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L5 Exploring Inclusion in the Space Industry 2

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete the planning for the showcase poster and complete poster in a follow-up class.

Extension: For a longer lesson, summarise the key takeaways from the discussion and ask learners to share their thoughts and ideas for fostering a more inclusive space industry. See the Teacher's Guide for a list of questions and links used to extend the discussion

Option B: In the follow-up class, use any remaining time to explore challenges faced by Indigenous and people of colour in the space industry, such as gender bias, lack of representation, and and barriers to advancement

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Challenges and Opportunities For Integrating Indigenous Knowledge into Space Legal Frameworks https://www.unoosa.org/documents/pdf/copuos/lsc/2022/Technical_presentations/09_CANEUS_COPUOS_LSC_Presentation_April_6_2022.pdf

What Can Indigenous Worldviews Bring to Space Exploration? As It Turns Out, a Lot. https://www.motherjones.com/politics/2022/04/what-can-indigenous-worldviews-bring-to-space-exploration-as-it-turns-out-a-lot/

Why indigenous tribes in the U.S. must have a voice in matters of space https://aerospaceamerica.aiaa.org/departments/why-indigenous-tribes-in-the-u-s-must-have-a-voice-in-matters-of-space/

Inspiring Black Youth through Outreach - Accessing Space [3:27mins] https://www.youtube.com/watch?v=P1PHJOOdmf8

Youtube playlist - Inclusion in Space seven videos from different perspectives on inclusion in space https://www.youtube.com/playlist?list=PLjvl2quYK9xz3s9MDPmAHyHtdMmQV2iId

Local Trip / Expertise / Additional Work and Assessments

Inclusive Space Explorer Showcase: Learners can create a presentation / exhibition in school or online showcasing the significant contributions to space exploration, that diverse individuals have made. Each group can undertake presenting their showcases to others in the class or in the school, or create short introductory videos, for an on line showcase. Learners could facilitate a discussion on the importance of representation and cultural diversity in shaping the future of space exploration and breaking barriers or innovation and how it contributes to innovation inspiring future generations of space professionals - see media box additional support.

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MM4: 5TG INDIGENOUS PEOPLE AND PEOPLE OF COLOUR SPACE PROFESSIONALS

List Indigenous and People of Color Space Professionals- a showcase

These These individuals have made significant contributions to space exploration and have broken barriers, inspiring others from diverse backgrounds to pursue careers and opportunities in the space industry.

1. Mae Jemison: First African American woman in space, flying aboard the Space Shuttle Endeavour in 1992. She is also a physician, engineer, and entrepreneur, founding the Jemison Group, a technology consulting firm.
2. Anousheh Ansari: Iranian-American engineer and entrepreneur who became the first self-funded woman to fly to space as a space tourist aboard the Soyuz TMA-9 spacecraft in 2006.
3. Ellen Ochoa: First Hispanic woman in space, flying aboard the Space Shuttle Discovery in 1993. She later served as the Director of the Johnson Space Center, becoming the first Hispanic director of a NASA centre.
4. Guion S. Bluford Jr.: First African American astronaut to fly in space, participating in four Space Shuttle missions between 1983 and 1992.
5. Joan Higginbotham: African American engineer and NASA astronaut who flew aboard the Space Shuttle Discovery in 2006, becoming the third African American woman to travel to space.
6. Jeanette Epps: NASA astronaut selected as part of the 2009 astronaut class, becoming the first African American woman to be assigned to the International Space Station (ISS) as a flight engineer for a future mission.
7. Charles F. Bolden Jr.: Former NASA astronaut and administrator, Bolden served as the first African American Administrator of NASA from 2009 to 2017.
8. Jose Hernandez: Mexican-American engineer and former NASA astronaut who flew aboard the Space Shuttle Discovery in 2009, becoming the first person to tweet in Spanish from space.
9. Franklin Chang-Díaz: Costa Rican-American former NASA astronaut and physicist who flew on seven Space Shuttle missions, tying the record for most spaceflights by an individual.
10. Jessica Watkins: NASA astronaut selected in 2017, Watkins will become the first African American woman to live and work on the Moon as part of NASA's Artemis program.

MM4: 5WS INDIGENOUS PEOPLE AND PEOPLE OF COLOUR SPACE PROFESSIONALS

Assigned Space Professional:

Background:

Space Sector / Profession:

Contributions to the Space Industry:

Anecdotes / Facts:

Create a showcase poster: Each member of the group should take one of the bullets below and include the following points on your poster.

- **A brief biography of the space explorer, highlighting key milestones and achievements.**

- **Images or photographs depicting the space explorer in action or participating in space missions.**
    - Make sure you have permission to use the image (s)you have selected
    - Download and save your images to your online learner folder space - by right-clicking the image, select save as image, naming it clearly and save

- **Quotes or inspirational messages from the space explorer.**

- **Optional: Fun facts or trivia about the space explorer's life and career**

MM4:5WSB PLANNING YOUR POSTER

Points to consider when planning you showcase poster and choosing a template:

1. Choosing a Layout/Template:

- Balance between text and visuals: Select a template that offers space for both written content (biography, quotes) and visuals (images, photographs). Ensure it's easy to read and visually appealing.
- Sections: Choose a design that allows you to organise content into clear sections (e.g., "Biography," "Key Milestones," "Quotes," "Fun Facts") so the viewer can navigate the poster easily.
- Image placement: Choose a template with designated spaces for images, ideally near or alongside the text they relate to (e.g., images of space missions next to key milestones).

2. Biography Section:

- Brief, impactful biography: Ensure the biography section is concise with key life milestones (e.g., education, career beginnings, major space missions). Highlight significant achievements such as space missions, leadership roles, or contributions to space science.
- Text formatting: Use bullet points or short paragraphs to keep it clear and readable. Avoid long blocks of text.

3. Images or Photographs:

- Choose high-quality images: Use clear, high-res. images of the space explorer, showing them in action (e.g., during space missions, training, or key moments in their career).
- Captions: Add short captions to the images to explain what's happening or the significance of the moment.

4. Quotes or Inspirational Messages:

- Highlight with design: Use a distinct font or colour for quotes to make them stand out. Place them in visually prominent spots on the poster, like near the top or in the middle, where they'll catch attention.
- Relevance: Select quotes that reflect the space explorer's philosophy, motivation, or views on space exploration and science.

5. Fun Facts or Trivia (Optional):

- Placement: Set aside a small section for "Fun Facts" that's separate from the main biography. This could be at the bottom or in the side margins for easy visibility.
- Engage your audience: Include interesting, lesser-known facts (e.g., personal hobbies, unique experiences in space, or unexpected career paths) to make the space explorer more relatable.

6. Design and Visual Appeal:

- Color scheme: Consider Choosing colours that align with the space theme (e.g., dark blues, blacks, and silvers) and that also make the text and images stand out.
- Typography: Ensure the font size is large enough for easy reading, with headings and key information in bold or larger fonts.

7. Conclusion / Call to Action (Optional):

- Closing thought: Include a final section summarising the impact and contributions or encouraging others to explore careers in space.

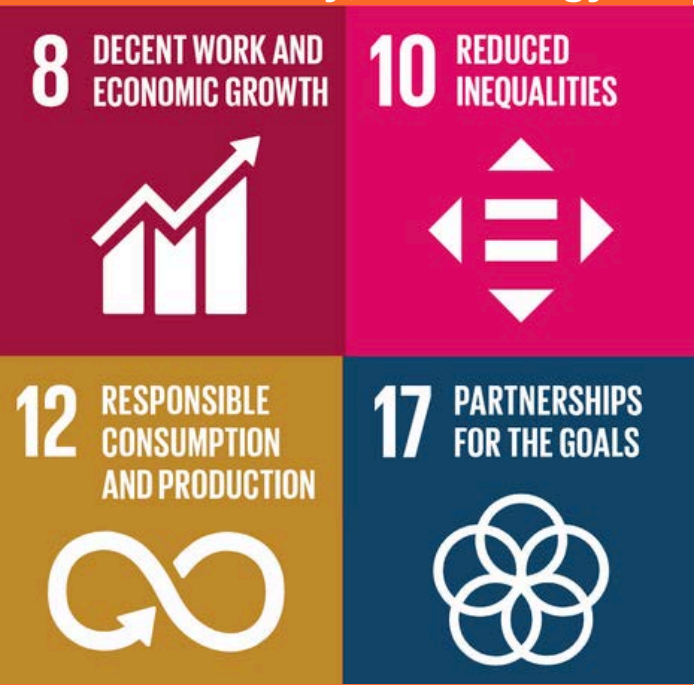
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 6 Exploring Inclusion in the Space Industry 3

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Exploring Inclusion in the Space Industry 3

In these three, linked lessons, learners will consider the importance of diversity and inclusion in space entrepreneurship, with a focus on the participation of women, indigenous communities, people of colour, and differently-abled individuals.

By recognising and celebrating diverse perspectives and contributions, a more equitable and innovative future for space exploration and beyond, can be created. By understanding the value of representation and equity, learners will be equipped to advocate for a more inclusive space economy.

Lesson 6, focuses on showcasing differently-abled professionals highlighting challenges and opportunities of promoting inclusive practices in space-related industries, identifying the barriers that marginalised groups face and considering ways to overcome them.

Vocabulary: Differently-abled, Diversity, Equity, Inclusion, Indigenous, Representation

In this lesson, the learner will:

- understand the role of differently-abled professionals in the space industry
- identify opportunities and challenges in promoting inclusion in the space industry
- consider the social and ethical implications of lack of diversity in the space industry
- critically consider the need to promote inclusion and diversity in future space industries

Materials

- Worksheet: Differently-Abled Space Professionals
- Worksheet: Planning Your Poster
- Teacher's Guide: Differently-Abled Space Professionals
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L6 Exploring Inclusion in the Space Industry 3

Activity Instructions

Activity 1: Differently-Abled Space Professionals - a showcase (25 mins)

1. Working in groups of four, assign learners one of the Space Professionals from the Teacher's Guide: Differently-Abled Professionals to research as the focus of their showcase.
2. Ask learners to gather the following information for their assigned professional

    - Background:
    - Space Sector / Profession:
    - Contributions to the Space Industry:
    - Anecdotes / Facts:

3. Remind learners to divide the task equally, with each member responsible for one of the research points and the worksheet is completed on time.

Activity 2: Create a Showcase Poster (25 mins)

1. Continuing to work in their groups, learners will organise their information on their assigned professional to create a showcase poster.
2. Using the Worksheet: Planning Your Poster, learners will plan their poster's layout and design to enable them to create a clear, engaging showcase poster that effectively communicates the space explorer's achievements and story
3. Once their planning is complete ask learners to log into Canva or access a lesson you have set up previously in Canva www.canva.com/education - see module overview for set up details.
4. Ask learners to select a template that reflects their planning and assign each member of the group to take one of the bullets below

    - A brief biography of the space professional, highlighting key milestones and achievements.
    - Images/photographs depicting the space explorer in action or participating in space missions.
    - Quotes or inspirational messages from the space explorer.
    - Optional: Fun facts or trivia about the space explorer's life and career

5. Circulate encouraging groups to develop their template using the worksheet guidelines

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L6 Exploring Inclusion in the Space Industry 3

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete the planning for the showcase poster and complete poster in a follow-up class.

Extension: For a longer lesson, summarise the key takeaways from the discussion and ask learners to share their thoughts and ideas for fostering a more inclusive space industry. See the Teacher's Guide for a list of questions and links used to extend the discussion

Option B: In the follow-up class, use any remaining time to explore challenges faced by differently-abled individuals in the space industry, such as bias, lack of representation, and barriers to advancement.

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Astroaccess Ambassadors https://astroaccess.org/ambassadors/

ESA Fly! Feasibility
https://www.esa.int/About_Us/Careers_at_ESA/ESA_Astronaut_Selection/ESA_s_feasibility_study_Fly%21

'It was magical' - meet the first disabled crew to fly in zero-gravity
https://www.bbc.com/news/disability-58902088

OBSERVER: Towards equality in the cosmos and diversity & inclusion in the space sector
https://www.copernicus.eu/en/news/news/observer-towards-equality-cosmos-and-diversity-inclusion-space-sector#:~:text=The%20space%20sector%20has%20traditionally,of%20representation%20from%20diverse%20backgrounds.

Local Trip / Expertise / Additional Work and Assessments

IInclusive Space Explorer Showcase: Learners can create a presentation / exhibition in school or online showcasing the significant contributions to space exploration, breaking barriers and inspiring future generations of scientists, engineers, and explorers that diverse individuals have made. Each group can undertake presenting their showcases to others in the class or in the school, or create short introductory videos, for an online showcase.

Learners could facilitate a discussion with the on the importance and benefits of inclusive design and universal accessibility principles in space exploration and technology development.

MM4: 6TG DIFFERENTLY-ABLED SPACE PROFESSIONALS

List of Differently-Abled Space Professionals - a showcase

These individuals have made significant contributions to space exploration and have broken barriers, inspiring others from diverse backgrounds to pursue careers and opportunities in the space industry. These bios highlight the achievements of space professionals while showcasing the growing focus on differently-abled inclusion in space exploration.

1. Michael R. Clifford was a NASA astronaut who flew on three Space Shuttle missions. Despite being diagnosed with Parkinson's disease in 1994, Clifford continued his career as an astronaut and flew his last mission aboard Atlantis in 1996. He is an advocate for Parkinson's research and an inspiration for perseverance in the face of adversity.
2. Scott Kelly (Astronaut) is a retired NASA astronaut best known for spending nearly a year aboard the International Space Station (ISS) from 2015 to 2016 as part of a groundbreaking mission to study the effects of long-duration spaceflight on the human body. His twin brother, Mark Kelly, was also an astronaut, making Scott part of NASA’s famous Twin Study.
3. Haley Arceneaux (Commercial Astronaut) became the youngest American to travel to space as part of the SpaceX Inspiration4 mission in 2021. A childhood cancer survivor and physician assistant at St. Jude Children’s Research Hospital, Arceneaux is the first person with a prosthetic body part to fly in space, representing a milestone for disability inclusion in space exploration.
4. John McFall (Astronaut) a British Paralympian and physician, was selected as the European Space Agency’s first astronaut with a disability in 2022. McFall, who lost his right leg in a motorcycle accident, is part of ESA's efforts to explore how people with disabilities can participate in space missions, paving the way for more inclusive space exploration.
5. Lisa Nowak (Aeronautical Engineer and Former NASA Astronaut) is a former NASA astronaut and aeronautical engineer who flew aboard Space Shuttle Discovery in 2006. A Navy officer with an extensive career in space systems engineering, Nowak was part of the STS-121 mission, which focused on International Space Station (ISS) construction and maintenance.
6. Sina Bahram (Accessibility Advocate, North Carolina) is a computer scientist and accessibility advocate dedicated to creating inclusive experiences for people with disabilities. Although not directly involved in space exploration, Bahram’s work in promoting accessibility in technology is influential for projects like AstroAccess, aiming to ensure people with disabilities are included in space exploration.
7. Mary Cooper (Aerospace Engineering and Computer Science Student, Stanford University) is a promising aerospace engineering and computer science student at Stanford University. She is involved in the “Fly! Feasibility Project,” which aims to enable people with physical disabilities to participate in future space missions, contributing to research that advances inclusivity in human spaceflight.

MM4: 6TG DIFFERENTLY-ABLED SPACE PROFESSIONALS

List of Differently-Abled Space Professionals - a showcase

8. AstroAccess (Project for Disability Inclusion in Space Exploration) is a pioneering project that promotes disability inclusion in human space exploration by working to remove barriers that prevent people with disabilities from becoming astronauts. The project conducts research and parabolic flights to explore how space missions can accommodate diverse physical abilities, helping to pave the way for disabled astronauts in future missions.
9. Eric Ingram (Founder and CEO of SCOUT, Inc.) has a physical disability that limits his mobility, is the founder and CEO of SCOUT, Inc., a space technology company that focuses on improving spacecraft autonomy and navigation. Ingram is also an advocate for inclusion in space and was a participant in AstroAccess's first parabolic flight, which explored how differently-abled individuals could adapt to weightlessness and space environments.
10. Leah Stubbs (Engineer at NASA) is hearing impaired and works as an engineer at NASA, contributing to missions such as the Mars Perseverance Rover. Her work in communications technology and accessibility at NASA highlights the agency's commitment to ensuring that people with disabilities can thrive in technical roles within space exploration.

MM4: 6WS DIFFERENTLY ABLED SPACE PROFESSIONALS

Assigned Space Professional:

Background:

Space Sector / Profession:

Contributions to the Space Industry:

Anecdotes / Facts:

Create a showcase poster: Each member of the group should take one of the bullets below and include the following points on your poster.

- **A brief biography of the space explorer, highlighting key milestones and achievements.**

- **Images or photographs depicting the space explorer in action or participating in space missions.**
    - Make sure you have permission to use the image (s)you have selected
    - Download and save your images to your online learner folder space - by right-clicking the image, select save as image, naming it clearly and save

- **Quotes or inspirational messages from the space explorer.**

- **Optional: Fun facts or trivia about the space explorer's life and career**

MM4:6WSB PLANNING YOUR POSTER

Points to consider when planning you showcase poster and choosing a template:

1. Choosing a Layout/Template:

- Balance between text and visuals: Select a template that offers space for both written content (biography, quotes) and visuals (images, photographs). Ensure it's easy to read and visually appealing.
- Sections: Choose a design that allows you to organise content into clear sections (e.g., "Biography," "Key Milestones," "Quotes," "Fun Facts") so the viewer can navigate the poster easily.
- Image placement: Choose a template with designated spaces for images, ideally near or alongside the text they relate to (e.g., images of space missions next to key milestones).

2. Biography Section:

- Brief, impactful biography: Ensure the biography section is concise with key life milestones (e.g., education, career beginnings, major space missions). Highlight significant achievements such as space missions, leadership roles, or contributions to space science.
- Text formatting: Use bullet points or short paragraphs to keep it clear and readable. Avoid long blocks of text.

3. Images or Photographs:

- Choose high-quality images: Use clear, high-res. images of the space explorer, showing them in action (e.g., during space missions, training, or key moments in their career).
- Captions: Add short captions to the images to explain what's happening or the significance of the moment.

4. Quotes or Inspirational Messages:

- Highlight with design: Use a distinct font or colour for quotes to make them stand out. Place them in visually prominent spots on the poster, like near the top or in the middle, where they'll catch attention.
- Relevance: Select quotes that reflect the space explorer's philosophy, motivation, or views on space exploration and science.

5. Fun Facts or Trivia (Optional):

- Placement: Set aside a small section for "Fun Facts" that's separate from the main biography. This could be at the bottom or in the side margins for easy visibility.
- Engage your audience: Include interesting, lesser-known facts (e.g., personal hobbies, unique experiences in space, or unexpected career paths) to make the space explorer more relatable.

6. Design and Visual Appeal:

- Color scheme: Consider Choosing colours that align with the space theme (e.g., dark blues, blacks, and silvers) and that also make the text and images stand out.
- Typography: Ensure the font size is large enough for easy reading, with headings and key information in bold or larger fonts.

7. Conclusion / Call to Action (Optional):

Closing thought: Include a final section summarising the impact and contributions or encouraging others to explore careers in space.

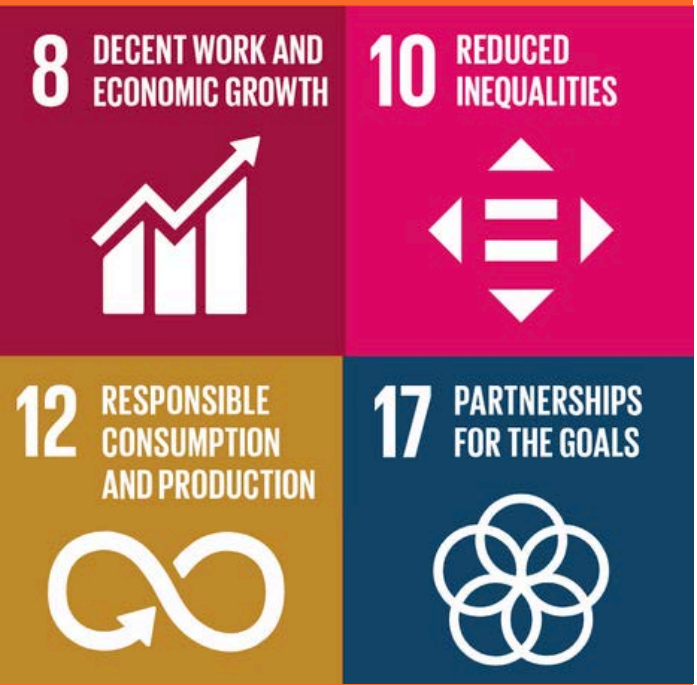
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 7 Exploring Open Innovation In Space

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Exploring Open Innovation in Space

This lesson introduces the concept of open source space entrepreneurship and innovation. Learners will examine initiatives driving innovation and democratising access to space technology and resources by looking at real-world examples.

In this lesson, learners will consider how collaboration, sharing knowledge and open source principles for design and innovation within space enterprise and entrepreneurship is beneficial. Learners will consolidate their learning by undertaking a rapid prototyping activity, to apply their learning by working as a team to iterate one of the ideas from the real-world examples.

Vocabulary: Decentralisation, Democratisation, Innovation, Open Source, Rapid Prototyping

In this lesson, the learner will:

- introduce the concept of open-source and collaborative communities in space enterprise and entrepreneurship, driving innovation and democratising access to space technology and resources.
- understand the significance of collaboration and open-source principles in the space industry.
- explore examples of successful open-source projects and collaborative communities in space enterprise and entrepreneurship.
- analyse the advantages of decentralised innovation and knowledge sharing in space exploration.

Materials

- Worksheet: Open Innovation in Space
- Worksheet: Open Innovation in Space - Projects
- Teacher's Guide: Open Innovation in Space
- Limited selection of crafting materials e.g. selection of cardboard (colour and texture), scissors, tape or glue
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L7 Exploring Open Innovation in Space

Activity Instructions

Activity 1: Open Innovation in Space (25 mins)

1. Using the Teacher's Guide: Open Innovation in Space, introduce the concept of open innovation and open source production and collaborative communities in space innovation and enterprise, driving innovation and democratising access to space technology and resources.
2. Alternatively, use the video: What is Open Innovation (4:11mins]
3. Working in pairs, ask learners to complete the Worksheet: Open Innovation in Space and using the companion Worksheet: Open Innovation in Space - Projects complete the tasks to help them gather information for Activity 2.
4. Remind learners they may need to split the task between them to enable them to complete the task in the time given.
5. Briefly summarise and discuss the advantages of open collaboration, knowledge sharing, and decentralised innovation in the space industry.

Activity 2: Rapid Prototyping - Space Challenge (25 minutes)

1. As a class, watch the Video: Rapid Prototyping [2:37] to see the steps in the process learners will use this to develop a rapid prototype. See also the Teacher's guide for additional support.
2. Working in pairs, ask learners to select one of the project examples from activity 1. This can be the one that interests them most or this can be randomly assigned. They will use this selection to create a rapid prototype.
3. Learners will have 20 mins after listening to the video to create a rapid prototype - the task is deliberately restricted by time and materials. This helps learners understand the concept of working quickly and using materials to show an idea to help others understand their vision.

- 10 mins to plan - use a timer
- 10 mins to build - use a timer

4. Use the reflection period to ask learners to present their prototype to another pair using the 321 method to focus their presentation to each other e.g. they share three things they learnt from the task, 2 things they found most interesting and their opinion about the activities.

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L7 Exploring Open Innovation in Space

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete Activity 1 and ask learners to share their example and one of the ways in which the example helps define one of the concepts from the table.

Extension: For a longer lesson, learners choosing the same example from Activity 1 can come together to discuss their prototype from Activity 2 with each other and how they could improve their ideas. Allow 10 minutes for this and at the end of the time ask the larger groups to share their iteration / improvements and how they think working as a team would be beneficial for innovation in the space industry.

Option B: Allow learners time to improve their prototype based on peer feedback or their experience of assessing their Rapid Prototype as a group, without the pressure of a timer. This helps to embed the concept of iteration and testing, two key phases in the Design Thinking process.

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

What is Open Innovation?[4:11mins] https://www.youtube.com/watch?v=GD2wCS2xwWQ

Rapid Prototyping [2:37] https://www.youtube.com/watch?v=oDdOqLblmVQ

Formlabs, Rapid Prototyping [5:11 mins] https://www.youtube.com/watch?v=-TDn25K-Jh4

Sprouts, The Design Thinking Process [3:56 mins] https://www.youtube.com/watch?v=_r0VX-aU_T8

Everything I knew about Open Source, Ben Cotton https://opensource.com/article/18/2/spacex

Enterprise Ireland European Space Agency Directory https://www.enterprise-ireland.com/en/supports/become-more-innovative/space-esa-homepage/esa-directory

Local Trip / Expertise / Additional Work and Assessments

Explore ESA's Enterprise Ireland's Irish Space Directory and research any of the organisations who are using open source principles, software or working as collaborative communities.

Invite a guest speaker from a space-related organisation or initiative that embodies the principles of open collaboration and innovation e.g.CubeSat project learners can explore the challenges and opportunities associated with open collaboration in the space industry.

MM4: 7TG INTRODUCTION TO OPEN SOURCE INNOVATION IN SPACE

Introduction to Open Innovation and Open Source

Background Videos: Use these short videos to developing an understanding of Open Innovation and Open Source so you can briefly introduce key ideas at the start of the class.

You can also share then with you class and watch them together depending on time available or if you do flipped class rooms you can ask them to watch at home in advance of the next class.

What is open Innovation? https://www.youtube.com/watch?v=GD2wCS2xwWQ - gives an overview of Open Innovation, including the models of Open Innovation

What Is Open Source? | An introduction to open technology https://www.youtube.com/watch?v=Po-WbVjPxCI Breaks down exactly what open source is, highlight the differences between the levels of projects, and give you some encouragement for what to look for when you're ready to start contributing to a project.

Open Source & Innovation: Key Differences and Everyday Examples in 60seconds https://www.youtube.com/watch?v=UoE6I9vrXRI Short video sharing simply the difference between these two key terms, which although closely linked have key diferences

Lego Ideas - https://ideas.lego.com/ enables Lego creators to share their creations and creativity, enter challenges, showcase their proposals for new LEGO Ideas sets and vote for awesome models dreamt up by fellow fan designers

Activity 1: The aim is to keep students engaged and learning through exploration, while you serve as a guide rather than a content provider. After a brief explanation of the task that this is about learning through discovery and research, not memorisation. It is important that they undersand the key tasks so although it is on their worksheet; stating clearly and clarifying expectations will be useful. Key tasks are as follows:

- Research each concept.
- Find relevant examples using the links or internet searches.
- Write a short explanation connecting the concept to an example.

Let them know they will spend approximately 15 minutes researching and 10 minutes writing as this can help them manage their time while understanding how much is required. Even though there are set examples encourage them to do some additional independent research

As you monitor the room, you can check in on progress, making sure students are engaging with the resources and support them without solving it for them, using open-ended questions and encourage critical thinking e.g.

- What do you think this concept might mean? or
- Have you tried looking at the provided links?
- How does this example show democratisation?" to push deeper understanding.

Encourage learners to collaborate once they have done some research, written their explanations. If you have more time you can ask them to group together in fours and share and compare their findings.

After 15 minutes of research, remind students to start writing their explanations, if they haven't already done so - calrifying they should write 1-2 sentences for each concept, linking it to an example. Again depending on time available learners could briefly share one example they found interesting with the class.

Tips

- Foster Engagement: Promote the use of different resources, and encourage students to cross-check information they find online.
- Keep Time in Mind: Make sure students stay on track and remind them of time checkpoints.

Activity 2 Rapid Prototyping

This activity helps learners experience the speed and adaptability of rapid prototyping in a practical, engaging way. After watching the video Ensure learners understand the key steps of rapid prototyping (planning, building quickly, using simple materials).

Make sure Learners understand they are to select one project from Activity 1 (CubeSat, Open Lunar Foundation, etc.) as inspiration in which they will create a rapid prototype, using the skills from the video to show an improvement to the project they have selected e.g. cubesats can are small and easy to make and cheap to launch and used for low orbit purposes remote sensing, weather monitoring - so an iteration could be design a Cubesat kit that could enable schools to design a moon mission, or monitor space debris. A prototype could show scale, functionality or design and will help them visualise their idea and share with others.

Emphasise time limits and simple materials to simulate real-world constraints and set a timer for 10 minutes. This is their planning time they can sketch, outline and discuss their ideas on how they will represent their idea visually and practically, ensure pairs are discussing and sharing ideas effectively. They will answer the questions on the Worksheet: Open Innovation in Space - Projects to help them plan their prototype. You can project the questions on the next page to help them plan their prototype

When the timer goes of, set a second 10-minute timer - this is their building phase. Learners build their prototype using basic materials (paper, cardboard, markers, etc.). After the timer ends, ask pairs to briefly present their prototype to another pair or to the class. Remind learners to focus on showing their idea, not on perfection.

MM4: 7TG INTRODUCTION TO OPEN SOURCE INNOVATION IN SPACE

1. Empathise: Think about how your idea will help to solve the problem and who might be involved in the problem. This will help you decide how you are going to address the problem.
2. Define: What is the problem your selected example is trying to fix or address. This is the same problem your prototype will have to address.
3. Ideate: What aspect of the problem will you address - will it be a new feature, new materials etc?

    - What is the primary goal / function of your innovation or idea?
    - What do you want your innovation to do / to achieve?
    - What specific tasks or experiments will it need to accomplish?
    - What performance criteria does the prototype need to meet e.g., accuracy, speed, endurance ?
    - What essential features and capabilities are required for your innovation idea?
    - How will your innovation contribute to scientific knowledge or technological advancement within Space Exploration?
    - What issues will you need to think about in the design / build of your prototype?

    - How will it be powered?
    - Will it need to communicate data? How will it do that?
    - Are there any health and safety issues? If so, what are they?
    - Will it need to withstand any environmental factors e.g. temperature, radiation, vacuum?
    - How will it get to space?
    - Think about the materials you will use, and how you will show this on your prototype
    - Think about wow will you show the different parts / function with the materials you have

4. Prototype: Think about what aspect of your selected inspiration example you want to iterate / explore prototype. Think about how you will iterate (improve, redesign, innovate) from the original example that is your inspiration - this is important as open source iterates other ideas and shares knowledge as part of its process. This is why you must share and publicly acknowledge your sources - so it's fair.

5. Test: How might you test your ideas, who could you talk with to get some feedback on your innovation and prototype.

In this instance, learners can share with a pair and use the 321 method to focus their feedback.

MM4: 7WS INTRODUCTION TO OPEN SOURCE INNOVATION IN SPACE

Activity 1: Exploring Concepts in Open Source Projects

This activity will introduce you to key Concepts related to open-source space projects and how they apply in real-world scenarios. You will use the given project examples to illustrate the definitions and key terms.

Below are 5 important concepts linked to open-source space projects. You will complete the following three tasks

- Understand what each concept means.
- Use the open-source space projects examples - Worksheet: Open Source project examples and additional online research.
- Write a brief explanation and example for each concept, in the table below, in your notebook or a digital table you have created online.

KEY TERM	Your Explanation
Decentralisation	
Democratisation	
Innovation	
Open Source	
Rapid Prototyping	

Remember: Use the Task Support help on the next page and the worksheet with the project exmaples to help you complete the table

MM4: 7WS INTRODUCTION TO OPEN SOURCE INNOVATION IN SPACE

Decentralisation - NOT Centrally controlled

- Find an example where power or control is distributed (shared) among a network rather than concentrated in one central place or authority.
- Hint: Think about how open-source space projects allow people from all over the world to contribute.

Democratisation - the process that enables people to have a voice and power

- Task: Look for an example where space technology or data is made accessible to a wide audience, not just governments or large companies.
- Hint: Consider CubeSats or projects that make space exploration available to universities or individuals.

Innovation -

- Task: Find an example of a creative or new solution that changes how things are done in space technology or exploration.
- Hint: Look for something unique, like a new type of satellite or a new way to collaborate on space missions.

- Open Source
  - Task: Identify an open-source project where anyone can access and contribute to the software or hardware.
  - Hint: Think about satellite programs that share their designs and tools for free.
- Rapid Prototyping
  - Task: Look for an example where new designs or technologies are quickly created and tested.
  - Hint: CubeSats or open-source hardware might help speed up development.

Look at the companion Worksheet: Open Innovation in Space - Projects for details on the projects below

- CubeSats
- Open Source Satellite Programs
- Open Lunar Foundation
- NASA Open Source Software
- SpaceX Open Source Initiatives

After you have found examples for each concept, write 1-2 sentences explaining the concept and how the example you found illustrates it.

MM4: 7WSB OPEN INNOVATION SPACE PROJECTS

Activity 1: Exploring Concepts in Open Innovation - Project Examples

- CubeSat: CubeSats are a class of nano-satellites that use a standard size and form factor these are small satellites typically built using off-the-shelf components and open-source hardware and software. CubeSats have revolutionised space exploration by enabling universities, research institutions, and even individuals to design, build, and launch their own satellites at a fraction of the cost of traditional satellites. Projects like the CubeSat Kit developed by NASA and the CubeSat standard developed by the California Polytechnic State University are examples of open initiatives that have democratised access to space. https://www.esa.int/Enabling_Support/Preparing_for_the_Future/Discovery_and_Preparation/CubeSats

- Open Source Satellite Programs: Organisations like Libre Space Foundation are dedicated to developing open-source hardware and software for satellite missions. They provide resources, tools, and platforms for collaboration among engineers, developers, and space enthusiasts worldwide. Their projects include ground stations, satellite tracking software, and mission control systems, all of which are freely available for anyone to use and contribute to. https://www.opensourcesatellite.org/

- Open Lunar Foundation: This organisation is focused on democratising access to the Moon by promoting open collaboration and resource-sharing among stakeholders in the space industry. They advocate for principles of transparency, inclusivity, and sustainability in lunar exploration and development, with the goal of enabling diverse participation and innovation. https://www.openlunar.org/

- NASA Open Source Software: CODE is a framework for the control and observation of resources, services, and applications. The technology supports the secure and scalable transmission of observed information to other programs, and it enables the secure execution of actions on remote computer systems. https://code.nasa.gov/

- SpaceX Open Source Initiatives: SpaceX, a leader in commercial space exploration, has released some of its software and hardware designs as open source. For example, the company's Dragon spacecraft avionics software is available on GitHub, allowing developers to contribute improvements and innovations. Additionally, SpaceX has open-sourced its mission data analysis tools, providing researchers and engineers with valuable resources for analyzing spacecraft telemetry data.

- Open Source Space Telescope: The Open Source Space Telescope project aims to design and build a low-cost, open-source space telescope that can be launched and operated by universities, research institutions, and amateur astronomers. By leveraging open collaboration and community involvement, the project seeks to make space-based astronomy more accessible and affordable for a wider range of users.
    -

MM4: 7WSB OPEN INNOVATION SPACE PROJECTS

Activity 1: Exploring Concepts in Open Innovation - Project Examples

Once the timer starts, you will work quickly with your partner to use your selected example as the starting point for the prototype. Complete the following question prompts for each stage of the design thinking process to help you think through some ideas before you start to prototype - you will have 10 mins.

Although you will work quickly there are some steps you can take to make sure you are still focused on your design problem.

1. Empathise: Think about how your idea will help to solve the problem and who might be involved in the problem. This will help you decide how you are going to address the problem.
2. Define: What is the problem your selected example is trying to fix or address. This is the same problem your prototype will have to address.
3. Ideate: What aspect of the problem will you address - will it be a new feature, new materials etc?

    - What is the primary goal / function of your innovation or idea?
    - What do you want your innovation to do / to achieve?
    - What specific tasks or experiments will it need to accomplish?
    - What performance criteria does the prototype need to meet e.g., accuracy, speed, endurance ?
    - What essential features and capabilities are required for your innovation idea?
    - How will your innovation contribute to scientific knowledge or technological advancement within Space Exploration?
    - What issues will you need to think about in the design / build of your prototype?

    - How will it be powered?
    - Will it need to communicate data? How will it do that?
    - Are there any health and safety issues? If so, what are they?
    - Will it need to withstand any environmental factors e.g. temperature, radiation, vacuum?
    - How will it get to space?
    - Think about the materials you will use, and how you will show this on your prototype
    - Think about wow will you show the different parts / function with the materials you have

4. Prototype: Think about what aspect of your selected inspiration example you want to iterate / explore prototype. Think about how you will iterate (improve, redesign, innovate) from the original example that is your inspiration - this is important as open source iterates other ideas and shares knowledge as part of its process. This is why you must share and publicly acknowledge your sources - so it's fair.

5. Test: How might you test your ideas, who could you talk with to get some feedback on your innovation and prototype.
    -

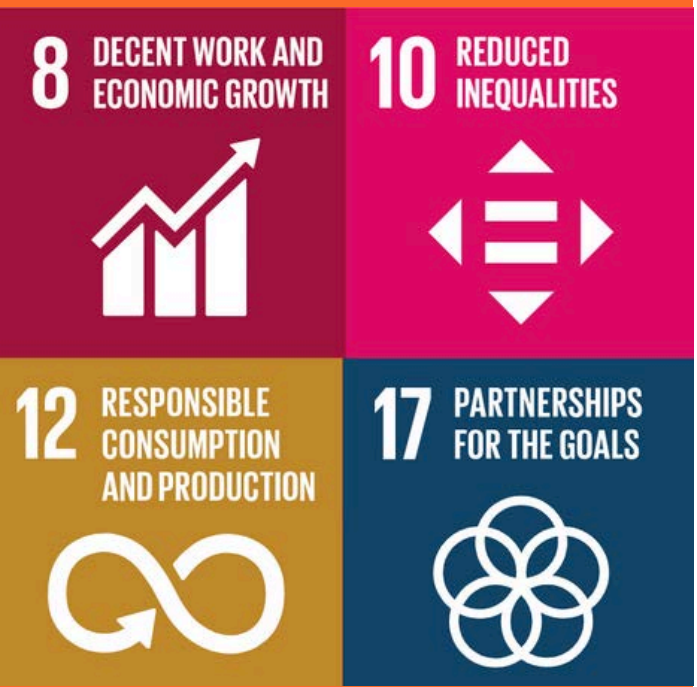
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 8 Engineering Space Tourism

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Engineering Space Tourism

In this lesson, learners will get an overview of the emerging Space Tourism sector. They will examine current and future possibilities for civilian space travel and reflect on the ethical considerations and challenges in commercialising space for tourism.

Learners will undertake an individual analysis and then a collaborative comparative analysis of three commercial spacecraft and their specifications. Learners will research the spacecraft's key features, capabilities, and technologies utilised in each spacecraft, such as propulsion systems, aerodynamics, and crew safety.

This lesson can be delivered as a stand alone lesson or used as the scaffolding lesson for a linked lesson, Lesson 9, that supports learners to imagine and plan their own space venture.

Vocabulary: Civilian Space Flight, Commercialisation, Launch Systems,

In this lesson, the learner will:

- gain insight into the emerging space tourism industry.
- gain insights into the design and engineering involved in
- explore the potential for civilian space travel in the near future.
- investigate the ethical dilemmas associated with commercialising space for tourism.
- engage in discussions to cultivate critical thinking and creativity in approaching space challenges.

Materials

- Worksheet: Engineering Space Tourism
- Teacher's Guide: Engineering Space Tourism
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L8 Engineering Space Tourism

Activity Instructions

Activity 1: Exploring Commercial Spacecraft (25 mins)

1. Working in pairs, assign numbers 1 - 3 in rotation until all pairs in the class have a number.
2. Learners' will research their assigned commercial spacecraft designed for civilian space travel, depending on their number using Worksheet: Engineering Space Tourism.Learners should use official websites, news articles and scientific publications to gather information on the space crafts specifications.
3. Use a timer to allow learners 10 mins to research their assigned spacecraft.
4. On completion, learners should find another pair with a different spacecraft and share their findings, compare notes.
5. Ask learners to identify similarities and differences between the spacecraft.
6. Depending on time, also ask learners, with the the same assigned spacecraft to share their findings with the class to see if they have the same findings. This can be carried out as a verbal 'round-robin'.

Activity 2: Future possibilities, Challenges and Opportunities (25 mins)

1. Working in the same pairs, learners should choose another spacecraft to research.
2. Using Worksheet: Future Possibilities and Opportunities to complete a second table.
    - Learners will focus on the future plans, developments and upgrades that the companies are planning.
    - Learners will consider the ethics and sustainability of the ventures based on what they have learned
3. Use the remaining time to discuss the learners' perspectives on space tourism.
4. If undertaking lesson 9, ask learners to begin thinking about what sort of Space Tourism venture they might create, this can be playful and creative, exploring the following questions e.g.
    - where will it go, does it have a name?
    - who lives there?
    - what will tourists do?

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L8 Engineering Space Tourism

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete Activity 1 only

Extension: For a longer lesson, host a walking debate with 3 or 4 questions to expand learners' critical thinking. Some key questions could be around the environmental impact, equitable access, responsible tourism or ethical integrity of the venture e.g.

- Should businesses be legally required to prioritise environmental sustainability over profit, even if it means higher costs for consumers?
- Is it fair for advanced technologies to be available only to wealthy countries or individuals, or should access to innovation be a global right?
- Should certain natural or cultural sites be off-limits to tourists to preserve them, even if it limits economic opportunities for local communities?
- Can a company truly be considered ethical if its business practices benefit some people but harm others in different parts of the world?

See Teacher's Guide for more prompt questions

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Virgin Galactic launches civilian crew to edge of space in historic flight [2:17] https://www.youtube.com/watch?v=JVa1Ntq5hjQ

First all-civilian space crew blasts off on SpaceX rocket [2:53 mins] https://www.youtube.com/watch?v=Bh6K1KylFgo

New Shepard Human Flight History [2.23] https://www.youtube.com/watch?v=dgAXeB16SoY

Enterprise Ireland European Space Agency Directory https://www.enterprise-ireland.com/en/supports/become-more-innovative/space-esa-homepage/esa-directory

Local Trip / Expertise / Additional Work and Assessments

Explore ESA's Enterprise Ireland's Irish Space Directory and research any of the organisations who are using open source principles, software or working as collaborative communities.

Learners could also create a presentation highlighting the unique strengths and weaknesses of their assigned spacecraft and provide insights into the broader landscape of commercial spaceflight.

MM4:8TG ENGINEERING SPACE TOURISM

Engineering Space Tourism: Space Craft Background

SpaceX's Crew Dragon:

- SpaceX's Crew Dragon, also known as Dragon 2, is a crewed spacecraft developed by SpaceX, the aerospace company founded by Elon Musk. It is designed to transport astronauts to and from the International Space Station (ISS) as part of NASA's Commercial Crew Program. Crew Dragon is equipped with advanced safety features, including an abort system that can quickly propel the spacecraft away from the rocket in the event of an emergency. It made its maiden uncrewed test flight, Demo-1, in March 2019, followed by the Crew Dragon Demo-2 mission in May 2020, which marked the first crewed flight of the spacecraft and the first crewed launch from American soil since the Space Shuttle program ended in 2011.

Blue Origin's New Shepard:

- New Shepard is a suborbital spacecraft developed by Blue Origin, an aerospace company founded by Jeff Bezos, the CEO of Amazon. Named after astronaut Alan Shepard, the first American to journey into space, New Shepard is designed for space tourism and suborbital research missions. The spacecraft consists of a crew capsule mounted on top of a reusable rocket booster. It is capable of carrying up to six passengers to the edge of space, where they experience a few minutes of weightlessness before returning to Earth. New Shepard has completed multiple successful test flights since its first launch in April 2015, demonstrating its reliability and safety for future commercial operations.

Virgin Galactic's Spaceship Two:

- SpaceShipTwo is a suborbital spaceplane developed by Virgin Galactic, a spaceflight company founded by Sir Richard Branson. It is designed to carry paying passengers on brief journeys into space, offering them the opportunity to experience weightlessness and observe the curvature of the Earth from above. SpaceShipTwo is launched from a carrier aircraft, WhiteKnightTwo, at high altitude before igniting its rocket engine to ascend to the edge of space. Once in space, the spacecraft's passengers are able to unstrap from their seats and float freely in the cabin for a short period before returning to Earth. Virgin Galactic has conducted numerous test flights of SpaceShipTwo, with plans to begin commercial operations in the near future.

MM4:8TG ENGINEERING SPACE TOURISM

List of debate and additional discussion questions

These questions can serve as a starting point for discussions and considerations regarding the sustainability and ethics of space tourism, encouraging thoughtful reflection and dialogue on these important topics.

Environmental Impact:

- Debate Question: Does space tourism contribute to environmental degradation, such as carbon emissions from rocket launches and space debris accumulation in Earth's orbit?
- Discussion questions: What measures can space tourism companies implement to minimise their environmental footprint, such as developing greener propulsion technologies or offsetting carbon emissions?
- How might the preservation of Earth's delicate ecosystems be balanced with the pursuit of space exploration and tourism?

Equitable Access:

- Debate Question: Space tourism should be more accessible to a broader and more diverse range of people, including those from underrepresented communities and developing countries?
- Discussion Questions: What barriers currently exist that prevent equitable access to space tourism, such as high costs, technological barriers, or geographic disparities?
- How can space tourism companies promote inclusivity and diversity within their workforce and customer base, ensuring that everyone has the opportunity to participate in the spacefaring experience?

Cultural Preservation:

- Debate Question: Does Space Tourism impact indigenous communities, cultural heritage sites, and sacred landscapes on Earth and potentially in space?
- Discussion Questions: What steps can space tourism operators take to respect and preserve cultural diversity, traditions, and heritage sites in the regions where they operate?
- How can space tourism contribute to cultural exchange, education, and appreciation of diverse cultures, languages, and traditions?

Responsible Tourism Practices:

- Debate Question: Should space tourism companies engage more with local communities and stakeholders to ensure that their activities benefit rather than harm the communities / places they launch from?
- Discussion questions: What ethical considerations should space tourists and operators keep in mind when visiting celestial bodies, such as the Moon or Mars, to avoid contamination, interference with scientific research, or damage to pristine environments?
- What codes of conduct or guidelines should govern space tourism activities to promote responsible behavior, safety, and sustainability in space and on Earth?

MM4: 8WS ENGINEERING SPACE TOURISM

Activity 1: Engineering Space Tourism

Using your assigned number, research the commercial space venture aligned to your assigned number. You will use your findings to undertake a comparative analysis with other classmates, once you have completed your research.

You will only have 10 minutes for this exercise, so allocate category

CATEGORY	1 SPACEX'S CREW DRAGON	2 BLUE ORIGIN'S NEW SHEPARD	3 Virgin Galactic's SpaceShipTwo
Tech specifications: • Dimensions • Payload capacity • Propulsion systems			
Mission Profiles: • Types of missions (e.g., orbital, suborbital), duration, • Destinations			
Commercialisation: • Target markets, • Pricing • Accessibility			
Safety and Reliability: • Abort systems, • Flight history, • Testing procedures			

MM4: 8WS ENGINEERING SPACE TOURISM

Activity 2 Future possibilities, challenges and opportunities

You will have 15 minutes to complete the table below on a different spacecraft / company than you have chosen for the first activity.

FUTURE PLANS	Details
Planned upgrades	
Upcoming Missions	
Potential advancements	
Crew Accommodation	
Accessibility	
Public Engagement and Education	
Interplanetary travel	

Once you have completed the table for Activity 2, you should consider with your partner the following in preparation for sharing with the class.

MM4: 8WS ENGINEERING SPACE TOURISM

Once you have completed the table for Activity 2, you should consider with your partner the following in preparation for sharing with the class.

Sustainability and Ethics

Environmental Impact:

- How does your project or idea minimize its impact on the environment?
- Are there any ways to reduce waste or use renewable resources in your venture?

Cultural Preservation:

- Does your project consider local cultures and traditions? How do you ensure they are respected and preserved?
- What steps can you take to avoid disrupting or commercializing cultural heritage?

Equitable Access:

- Who benefits from this project? How can you ensure it is accessible to diverse communities, regardless of socioeconomic status?
- Are there any barriers that might limit certain groups' access to your project? How can these be addressed?

Responsible Tourism (if applicable):

- If your project involves tourism, how do you promote responsible and respectful behavior among participants?
- How will you manage the balance between attracting visitors and maintaining the integrity of local environments and communities?

Long-Term Viability:

- How do you plan to sustain this project in the long run without compromising its ethical principles?
- What measures can you take to ensure that the project continues to benefit both people and the planet over time?

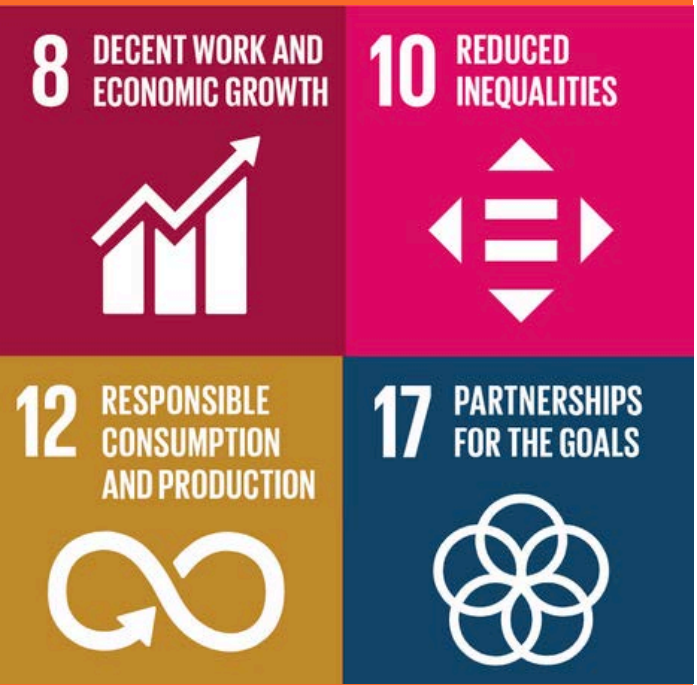
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 9 Engineering Space Tourism 2

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Engineering Space Tourism 2

In this lesson, learners will build upon their previous knowledge to develop a space venture focused on civilian space travel. They will collaborate to define the aims and objectives of their space tourism event, considering factors such as target audience, mission profile, and ethical considerations.

The core activity is designed for a full 1 hour lesson without the reflective exercise. The two activities presented could be extended, with Learners creating a logo that encapsulates the vision and values of their space venture in a following lesson.

Vocabulary: Civilian Space Flight, Commercialisation, Launch Systems,

In this lesson, the learner will:

- apply knowledge of space tourism concepts and principles to develop a civilian space travel event
- collaborate with peers to define the aims and objectives of the space venture, considering factors such as target audience, mission profile, and ethical considerations
- explore the interdisciplinary nature of space tourism, integrating concepts from science, technology, engineering, arts, and mathematics (STEAM) fields to develop a comprehensive space venture plan
-

Materials

- Worksheet: Creating a Space Tourism Event
- Worksheet: Peer Review:Space Tourism Event
- Teachers Guide: Enterprise Planning, Lesson 10
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L9 Engineering Space Tourism 2

Activity Instructions

Activity 1: Creating your Own Space Tourism Event (35 mins)

1. Introduce the activity and explain the goal, designing a Space Tourism Event
2. Working in pairs, (or small groups of 3-4) learners will use the worksheet: Create your own Space Tourism Event to prompt them to create their own event.
3. Crculate the room, encouraging them to go think think more deeply about their event design using questions e.g.

    - How will you ensure the event is environmentally sustainable?
    - "Who can access this event, and how will you ensure fairness?").

4. Emphasise that they need to consider environmental impact, ethics, equitable access, as these will be considered in the peer review

Activity 2: Peer review and Idea Improvement (25 mins)

1. Ask learners to swap their event designs with another pair or group if working in 3s or 4s.
2. Ask each group to review the other's event, providing written feedback, suggestions, and questions using the feedback section of the worksheet.
3. Encourage the learners to challenge each other's ideas using the prompt questions on the worksheet Peer Review: Space Tourism event

4. After 10 minutes, ask learners to hand back the feedback sheet to the original creators of the event.
5. Allow learners 10 minutes to review the feedback and refine their event based on the comments and questions from their peers.
6. Depending on time ask if any groups would like to share how the feedback they received improved or changed their event idea. This can also be used to highlight the importance of collaboration and iterative improvement in planning as well as focus the reflective 321 exercise.

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L9 Engineering Space Tourism 2

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete Activity 1 only and continue with activity 2 in a follow-on lesson

Extension: For a longer lesson, watch the video, How to design a great Logo and undertake activity 1 from lesson 10 Creating a logo for your Space Tourism business. Learners can develop a logo using online generators for the business that accompanies their space tourism event - see media box

Option B: Discuss some of the additional activities learners would have to consider if they were to seek investment for their imagined space venture. Use the teachers guide from Lesson 10 - Enterprise Planning for your Space Venture

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

How to design a great logo [3:09 mins] https://www.youtube.com/watch?v=DiVygGdXuHE

Business name generator:

- Shopify https://www.shopify.com/tools/business-name-generator?index
- Namelix https://namelix.com/

Logo Generators

- https://www.design.com/logo-maker
- www.Looka.com
- https://www.vistaprint.ie/logomaker
- https://www.adobe.com/express/create/logo
- www.canva.com
- www.wix.com

Local Trip / Expertise / Additional Work and Assessments

Learners can extend their space venture project by developing a business case overview. Using the Teacher's Guide and links in the Media Box learners and MM7: Problem to Pitch Space Challenge lesson 6 and 7 to develop a 'Pitch' Presentation and consider their market and business venture.

Explore ESA's Enterprise Ireland's Irish Space Directory and research any of the organisations who are using open source principles, software or working as collaborative communities.

MM4: 9WS CREATE A SPACE TOURISM EVENT

Activity 1: Planning your space tourism event

Use the table to help you develop your space tourism event by answering the questions using the prompts to help you plan your space tourism event. You can use the second page or a notebook to record your final answers for review by another group.

EVENT ASPECT	THINGS TO THINK ABOUT	NOTES
AIM: What is the aim of your space venture?	• To provide suborbital joyrides for thrills / pleasure to wealthy customers? • Or longer-duration orbital missions for scientific research or leisure purposes? • Or space public transport or any other ideas e.g. parties or celestial bodies viewing?	
Market: Who is your customer?	• Identify your customer based on what you decided was your aim. You will need to think about • Who they are, what they are interested in and their ability and willingness to pay	
Destination: Where are they going?	• Sub-orbital civilian flights to the edge of space? • Orbital mission to the International Space station? • Or a yet to be explored planet?	
Experience: What will be the overall experience?	• Functional, luxury or themed? • What facilities will there be? • Will it be like a cruise ship or more like an aeroplane? • If it is not research or educational design a memorable and immersive customer experience that aligns with the objectives of the space tourism venture. • Consider aspects such as pre-flight training, launch preparations, in-flight activities, accommodations, and post-flight celebrations or souvenirs	

MM4: 9WS CREATE A SPACE TOURISM EVENT

Activity 1: Planning your space tourism event

You can use this page or a notebook to record your final answers for review by another group.

EVENT ASPECT	THINGS TO THINK ABOUT
AIM: What is the aim of your space venture?	
Market: Who is your customer?	
Destination: Where are they going?	
Experience: What will be the overall experience?	

MM4: 9WSB PEER REVIEW: SPACE TOURISM EVENT

Activity 2: Peer Review your space tourism event

After reviewing another pair's / group's Space Tourism Event, use the following questions to help you provide thoughtful feedback. Consider the environmental, ethical, and practical aspects of your peer's design.

EVENT ASPECT	Feedback Considerations	FEEDBACK
Environmental Impact	Sustainability • Does the event design address environmental sustainability? If so, how? • What additional steps could be taken to reduce the environmental impact (e.g., waste reduction, energy use)? Carbon Footprint: • Has the group considered the carbon footprint of the event, especially regarding space travel? • How could they make the event more eco-friendly?	
Ethical Considerations	Cultural Sensitivity: • Does the event respect local cultures and traditions, particularly if it involves different locations on Earth or space habitats? • Are there any cultural or ethical aspects that could be improved? Long-Term Impact: • Does the event contribute positively to the space tourism industry or to local communities? • What measures could they include to ensure ethical integrity over time?	

MM4: 9WSB PEER REVIEW: SPACE TOURISM EVENT

Activity 1: Peer Review your space tourism event

After reviewing another pair's / group's Space Tourism Event, use the following questions to help you provide thoughtful feedback. Consider the environmental, ethical, and practical aspects of your peer's design.

EVENT ASPECT	Feedback Considerations	FEEDBACK
Equitable Access	Inclusivity: • Who is the target audience for this event? Is the event accessible to people of different economic or social backgrounds? • How could the event be made more inclusive? Cost: • Does the event seem affordable for a wide range of participants, or is it only accessible to the wealthy? • Suggest ways to make it more financially accessible to a broader audience.	
Event Feasibility and Creativity	Feasibility: • Does the event seem realistic and achievable with current technology and resources? • What challenges might they face in making the event a reality? Creativity: • How creative is the event concept? Does it bring new or innovative ideas to space tourism? • What elements of the event could be developed further to enhance its uniqueness? •	

MM4: 9WSB PEER REVIEW: SPACE TOURISM EVENT

Activity 1: Peer Review your space tourism event

After reviewing another pair's / group's Space Tourism Event, use the following questions to help you provide thoughtful feedback. Consider the environmental, ethical, and practical aspects of their design.

EVENT ASPECT	Feedback Considerations	FEEDBACK
Suggestions and Improvements	Overall Impressions: ◦ What did you like most about their event idea? ◦ What could be improved to make the event more compelling or sustainable? Open Feedback: • Any additional thoughts, questions, or feedback not covered in the prompts above?	

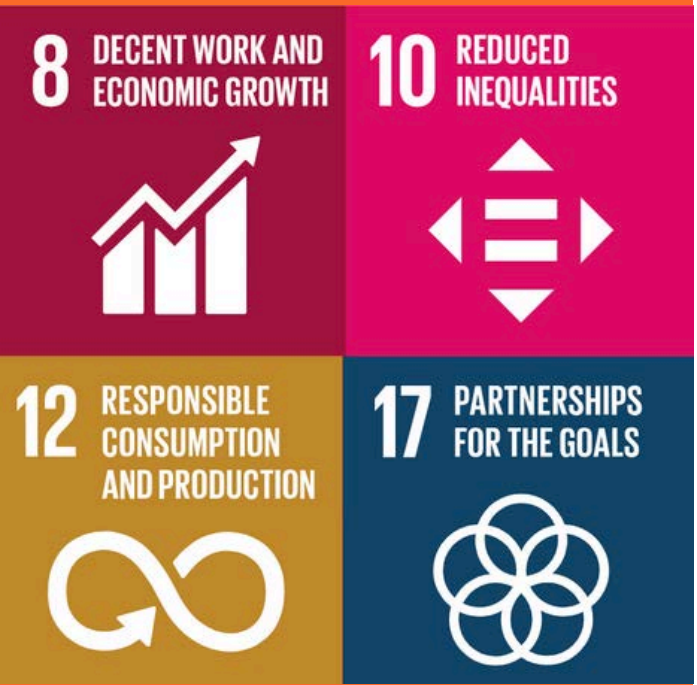
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 10 Engineering Space Tourism 3

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Engineering Space Tourism 3

n this lesson, learners will expand on their previous work by developing a space venture centered around civilian space travel. They will engage in creative thinking while exploring the growing industry of Space Tourism. Through this process, students will design key components for their venture, including a business name, a logo, and an investment pitch to attract potential investors.

This lesson can be combined with Lessons 8 and 9 to form a micro-project focused on Space Tourism. As part of the project, learners will enhance their understanding of the space tourism industry and develop entrepreneurial skills, culminating in a well-rounded venture proposal.

Vocabulary: Civilian Space Flight, Commercialisation, Space Tourism

In this lesson, the learner will:

- demonstrate their understanding of the Space Tourism industry by creating a business name and logo
- craft an investment pitch to communicate their space tourism concept effectively.
- engage in imaginative processes to design and present their business ideas within the context of an emerging industry.
- work in teams or pairs to complete a micro-project on Space Tourism, integrating lessons from previous activities.

Materials

- Worksheet: Generating a Space Tourism Logo
- Worksheet: Planning a Space Tourism Venture
- Worksheet: Lean Canvas
- Teachers Guide: Dragon's Den Event
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L10 Engineering Space Tourism 3

Activity Instructions

Activity 1 Create Logo for your Space Tourism Venture (25 mins)

1. Watch the video 5 Logo Design Tips to Help Fuel Your Creativity [3:09 mins] https://www.youtube.com/watch?v=DiVygGdXuHE
2. As a follow on lesson from lesson 9, ask learners to form their groups from the last lesson.
3. Learners will create a business summary to enable them to create a Logo for your Space Tourism Venture - model the activity using a Business Generator from the media box using this example

    - their business,- sub orbital pleasure trips and party events
    - industry, Space Tourism,
    - brand personality... quirky fun, customer focused

4. Ask learners to compete the first step in the Worksheet: Generating a Space Tourism Logo by creating a business summary to type into the name generator e.g. Space Tourism, sub orbital pleasure trips and party events, quirky fun, customer focused, that they will then use to create their logo.
5. Learners will then use one of the logo Generators on the worksheet (see also media box) to create a logo for their Space Tourism Event / Venture
6. Once they have completed their logo, they can upload to their e-classroom (Teams space or Google Drive) with their Space Venture Idea

Activity 2 Space Tourism Venture Pitch (25 mins)

1. Using the Worksheet: Planning a Space Tourism Venture, ask learners to develop their space tourism venture business plan.
2. Learners could also outline their business plan using the Worksheet: Lean Canvas for their space tourism venture as part of additional lessons or micro-project.
3. Encourage Learners to share their ideas with others and ask for help or feedback in terms developing their ideas particularly with thinking about potential clients or customers.

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L10 Engineering Space Tourism 3

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete Activity 1 only and undertake the other activity in a follow-up lesson.

Extension: For a longer lesson, learners can use a business card template from www.canva.com with their name, role in the business, contact details and logo to complete the project.

Option B: If using lessons 8 - 10 as a micro-project learners can continue to develop their business investment pitch over several lessons with presentations using the worksheet: Lean Canvas for a Dragon's Den style pitch event with their peers - see Teacher's Guide.

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

5 Logo Design Tips to Help Fuel Your Creativity [3:09 mins] https://www.youtube.com/watch?v=JVa1Ntq5hjQ oY

Space Tourism: Future of Travel [2:58] https://www.youtube.com/watch?v=PLOSY2zqExk

What Will Space Tourism Be Like? [5:19] https://www.youtube.com/watch?v=eH-xm9G9QBk

Canva Pitch Deck Templates https://www.canva.com/presentations/templates/pitch-deck/

11 Young Builders Pitch at the Largest Patch Showcase to Date https://dogpatchlabs.com/11-young-builders-pitch-at-the-largest-patch-showcase-to-date/

Enterprise Ireland European Space Agency Directory https://www.enterprise-ireland.com/en/supports/become-more-innovative/space-esa-homepage/esa-directory

Local Trip / Expertise / Additional Work and Assessments

Explore ESA's Enterprise Ireland's Irish Space Directory and research any of the organisations who are using open source principles, software or working as collaborative communities.

Learners could also create a pitch deck presentation for a Dragon's Den Style pitch event based on their Lean Canvas - see Teacher's Guide for planning and delivering a Dragon's Den event.

Invite a local entrepreneur or a professional in the aerospace industry to speak to the class. They can discuss the challenges of starting a business, innovation in space travel, or even environmental and ethical concerns in the field. This could help students refine their pitches and expand their understanding of the space tourism sector.

MM4: 10TG DRAGON'S DEN EVENT

Teacher's Guide: Developing a Dragon's Den-Style Event

This guide will help you organize a Dragon's Den-style event where learners pitch their space tourism ventures to a panel (the "Dragons") in a fun, interactive way. The event encourages creativity, entrepreneurial skills, and critical thinking, while making the process engaging for learners.

Preparation Before the Event

Set the Stage:

- Explain the Format: Introduce the concept of Dragon's Den or Shark Tank—a competition where entrepreneurs pitch their business ideas to potential investors.
- Learners will present their space tourism ventures to a panel of "Dragons" (this could be you, other teachers, or students playing the role of investors).

Pair or Group Work:

- Organise students into pairs or small groups. Each group will have created a space tourism venture with a business name, logo, and investment pitch.
- Ensure learners have completed their business name, logo, and pitch in advance.

Prepare the Dragons:

- Select the Dragons: You, other staff, or selected students can be the investors. They will ask critical questions and provide feedback after each pitch.
- Brief the Dragons: Explain that their role is to challenge the ideas, asking questions about feasibility, sustainability, ethical practices, costs, etc. The Dragons will decide which ventures they would hypothetically invest in.

Structure of the Event (50-60 minutes)

1. Introduction: Explain the rules of the event:
    - Each group will have 3-5 minutes to pitch their idea.
    - The Dragons will ask follow-up questions for 2-3 minutes after each pitch.

- Emphasise that the pitches should be engaging and convincing, covering:
    - The business name and logo.
    - The concept of the space tourism venture.
    - Its uniqueness, feasibility, and financial potential.
    - Environmental and ethical considerations.

Pitches (30-40 minutes):

- Groups take turns presenting their pitches. Ensure timing is strict to maintain the pace.
- After each pitch, the Dragons should ask 2-3 challenging questions (e.g., How will you ensure the sustainability of your venture? or What makes your project different from others in the industry?).

- The Dragons can take notes and rate each pitch based on pre-determined criteria (e.g., creativity, feasibility, ethical considerations, financial potential).

Deliberation and Feedback (10 minutes):

- After all pitches, the Dragons can deliberate, deciding which ventures they would invest in.
- Provide constructive feedback to each group based on their pitch, highlighting strengths and areas for improvement.

Announce the Winner(s) (5 minutes):

- The Dragons announce which venture(s) they would choose to invest in and explain why.
- Optionally, have prizes or certificates for the winning team(s).

Post-Event Discussion (Optional)

- Reflection on Learning (5-10 minutes):
  - Encourage students to reflect on the experience:
    - What went well in their pitch?
    - What would they improve next time?
    - How did they address ethical or environmental concerns?
  - Discuss how the entrepreneurial skills they learned could apply to future career paths.

Ideas for Certificates
You can award certificates that recognise various strengths in the event. These certificates will give learners positive recognition in areas where they excelled, motivating them to continue developing their skills. Here are some ideas for the titles of certificates:

- Best Pitch: Awarded to the team with the most convincing and well-structured presentation.
- Most Creative Concept: For the group that presented the most original or innovative idea.
- Best Environmental and Ethical Approach: For the team that excelled in addressing sustainability and ethical considerations.
- Most Investable Idea: For the venture that seems most likely to succeed from a financial standpoint.
- Best Teamwork: Recognizing the group that worked exceptionally well together.
- Audience Favorite (optional): If peers are voting, this certificate goes to the group that the audience thought was the most engaging or interesting.
- Outstanding Entrepreneurial Spirit: For a group that demonstrated excellent entrepreneurial thinking and enthusiasm.

MM4: 10TG DRAGON'S DEN EVENT

Dragon's Den Feedback Prompts

To help the Dragons (judges) provide structured, constructive feedback to the learners, you can use the following prompts. These will guide the Dragons in focusing on key areas of the pitch. Feedback Structure for Dragons

Creativity and Uniqueness:

- "What stood out about your concept was..."
- "I was impressed by how original your idea was because..."
- "One area where you could take the creativity even further is..."

Feasibility and Practicality:

- "Your plan seems realistic, especially when you considered..."
- "One challenge you might face is... How would you overcome that?"
- "To make your venture more feasible, you could think about..."

Financial Viability:

- "You've done a good job considering the costs, but have you thought about..."
- "I liked the way you plan to attract investors by..."
- "In terms of profitability, you might want to focus more on..."

Sustainability and Ethics:

- "Your consideration of the environment was impressive because..."
- "I'd suggest thinking more about how to reduce the environmental impact by..."
- "From an ethical perspective, how would you ensure..."

Presentation and Persuasion:

- "Your pitch was very convincing because..."
- "I enjoyed how clearly you explained your ideas, but one area to work on might be..."
- "To make your pitch even more persuasive, you could..."

MM4: 10WS GENERATING A SPACE TOURISM LOGO

Activity 1: Generating a Space Tourism Logo

Firstly select one of the business name generators

- Shopify shopify https://www.shopify.com/tools/business-name-generator?index
- Namelix https://namelix.com/

and use the information from your Space Tourism planning worksheet, from Lesson 9 e.g.

- what is your space tourism business,- sub orbital pleasure trips and party events
- industry, Space Tourism,
- brand personality... quirky fun, customer focused

to create your business summary which you will input to generate your business name e.g. Space Tourism, sub orbital pleasure trips and party events, quirky fun, customer focused

Once you have a business name, you will now use this name to create a Logo for your Space Tourism Venture

1. Watch the video 5 Logo Design Tips to Help Fuel Your Creativity https://www.youtube.com/watch?v=DiVygGdXuHE
2. Use one of the Logo Generators from the media box to create a logo for your Space Tourism Event / Venture
    - https://www.design.com/logo-maker
    - www.Looka.com
    - www.canva.com
    - https://www.vistaprint.ie/logomaker
    - https://www.adobe.com/express/create/logo
    - www.wix.com
3. Once you have completed your logo - upload to your e-classroom (Google Drive, Microsoft Teams or other online shared space) with your Space Venture Idea
4. If you are having a longer class you can use a business card template template from www.canva.com with your name, role in the business, contact details and logo

MM4: 10WS PLANNING A SPACE TOURISM VENTURE

Activity 1: Planning your space tourism venture

Use the table to help you develop the space tourism venture that will sell your space tourism event. The questions will help you plan your venture and you can use the second page or a notebook to record your final answers for review by another group.

BUSINESS DETAIL	BUSINESS CASE	NOTES
Marketing and Promotion: Who is your audience?	• Think about your marketing and promotion. How will you generate interest, raise awareness and attract your customers to your venture? • Who are your customers, what style of marketing attracts them, where will you find or connect to your customers? • Imagine how you might use traditional and digital marketing channels, social media platforms, public relations, events, and partnerships to reach target audiences effectively.	

Partnerships and Collaborations: Will you collaborate, get any sponsors? Why?	• Do you need any specialist expertise for your venture?
	  ◦ Aerospace companies
	  ◦ Space agencies
	  ◦ Tourism organisations
	  ◦ Catering
	• What resources do you need?
	• What networks could be useful to you?	

Experience: What will be the overall experience?	• Functional, luxury or themed? • What facilities will there be? • Will it be like a cruise ship or more like an aeroplane? • If it is not research or educational design a memorable and immersive customer experience that aligns with the objectives of the space tourism venture. • Consider aspects such as pre-flight training, launch preparations, in-flight activities, accommodations, and post-flight celebrations or souvenirs	

MM4: 10WS PLANNING A SPACE TOURISM VENTURE

Activity 1: Planning your space tourism venture

Use the table to help you develop the space tourism venture that will sell your space tourism event. The questions will help you plan your venture and you can use the second page or a notebook to record your final answers for review by another group.

BUSINESS DETAIL	BUSINESS CASE	NOTES
Safety:	• Prioritise safety and risk management throughout the planning process. • Identify potential hazards and risks associated with space travel, and develop protocols and contingency plans to mitigate them. • Consider factors such as crew training, medical requirements, emergency procedures, and insurance coverage.	
Regulatory Compliance:	• Familiarise yourselves with the regulatory frameworks governing commercial spaceflight, including licensing, permits, safety regulations, and liability issues. • Ensure compliance with applicable laws and regulations to operate the space tourism venture legally and responsibly.	
Financial Planning: Where are they going?	• You will need a comprehensive financial plan if anyone is to invest. You will need to consider factors such as spacecraft development, launch services, training facilities, marketing, and insurance and outline ◦ the initial investment required, ◦ operating costs, ◦ revenue projections, ◦ pricing strategies, and potential source of funding or investment. •	

MM2 10WSB: LEAN CANVAS

Problem
List your customer's top 3 problems

-worry that pet will get lost
-worry that pet is up to no good when home alone
-miss pet and want a way to connect while at work

Existing Alternatives
List how these problems are solved today

There are various collars on the market that track your pet's location. Some track steps and various other stats. There is a separate camera device that can be worn by your pet, but nothing exists that works as a GPS, camera and communication device in one.

Solution
Outline a possible Solution for each problem

worry that pet will get lost-you will be able to track your pet at all times.
worry that pet is up to no good when home alone-you will be able to see what your pet is doing at all times.
miss pet and want a way to connect while at work-you will be able to connect using your voice while you're away

Key Metrics
List the key numbers, that tell you how your business is doing

Number of units sold.

Unique Value Proposition
Single, clear compelling message, that turns an unaware visitor into an interested prospect

Love Paws makes it possible to be with your pet even when you're away.

High Level Concept
List your x for y analogy (e.g. youtube = flicker for videos

Love Paws is the Nest of pet tracking devices.

Unfair Advantage
Somthing, that can't be easily copied or bought

I am Cesar Milan, world famous dog trainer and I have my own TV show and numerous celebrity clients.

Channels
List your path to customers

Give away for free to celebrity pet owners and celebrity TV personalities on Animal Planet, then do a billboard, print and web and social media campaign.

Customer Segments
List your customer segments and users

Ideal customers are middle to high income, tech-savvy pet owners who spend a significant time away from their pets.

Early Adopters
List the characteristic of your ideal customer

Early adapters are pet owners who love to keep up and own the latest tech innovations as soon as they come out.

Cost Structure
List your fixed and your variable costs

Product design, sourcing of materials, production costs, engineering, marketing, PR.

PRODUCT

Revenue Streams
List your sources of revenue

We will initially sell online with the goal to being on the shelves of major pet stores by end of year.

MARKET

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

MM2 10WSB: LEAN CANVAS

PROBLEM

List your top 1-3 problems.

EXISTING ALTERNATIVES

List how these problems are solved today.

SOLUTION

Outline a possible solution for each problem.

KEY METRICS

List the key numbers that tell you how your business is doing.

UNIQUE VALUE PROPOSITION

Single, clear, compelling message that states why you are different and worth paying attention.

HIGH-LEVEL CONCEPT

List your X for Y analogy e.g. YouTube = Flickr for videos.

UNFAIR ADVANTAGE

Something that cannot easily be bought or copied.

CHANNELS

List your path to customers (inbound or outbound).

CUSTOMER SEGMENTS

List your target customers and users.

EARLY ADOPTERS

List the characteristics of your ideal customers.

COST STRUCTURE

List your fixed and variable costs.

REVENUE STREAMS

List your sources of revenue.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

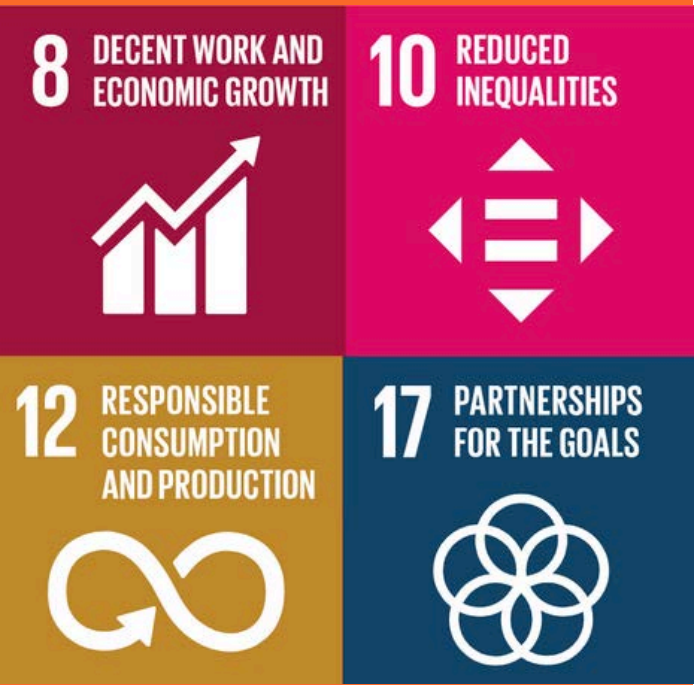
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 11 Exploring Space Careers

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Exploring Space Careers

In this lesson, learners are introduced to the range of career paths within the space industry. Through exploration and discussion, they gain insight into diverse roles such as aerospace engineering, astrophysics, space medicine, and space entrepreneurship. Learners will discover that the space industry offers diverse opportunities, each requiring unique skills, qualifications, and educational pathways.

Learners will begin to consider educational pathways, requirements and qualifications essential for pursuing careers in space-related fields. Learners are invited to consider their own career aspirations within the space industry and equipped with the knowledge to embark on their educational and professional journey towards fulfilling those goals.

Vocabulary: Aeronautics, Career Fields, Pathways

In this lesson, the learner will:

- begin to identify different career paths within the space industry
- gain an understanding of the educational pathways and qualifications required to pursue careers in the space industry
- explore career opportunities within the space industry, including roles in research and development, space exploration missions, space technology development, space policy and governance, and space business and entrepreneurship
- begin to evaluate and compare educational pathways and career options within the space industry based on their interests, skills, and long-term career goals

Materials

- Worksheet: Exploring Space Careers Challenge
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L11 Exploring Space Careers

Activity Instructions

Activity 1: Accessing Space - (20 mins)

1. As a class watch Video: 'You don't need an Aerodynamics Degree to get into the Space Industry - Accessing Space' [13:09 mins]
2. Ask learners to list how many different careers and college opportunities they heard in the video.
    - Astrophysics / Physics scientist
    - Aeronautical engineering and physics
    - Flight dynamics
    - Procurement for a satellite company
    - Satellite manufacturing
    - Space operations
    - Space operations centre construction
    - Regional growth of the space industry
    - Space Studies
    - Space grants, outreach and education
    - STEM focused careers
    - Thermal Engineer / Thermal Dynamics for Satellite Engineer
    - Data analysis space exploration
    - Design of space systems, processes and space craft
3. Allow extra time for learners to replay aspects of the video to gather as many careers as possible.
4. Go around the room asking how many different career or college opportunities they found

Activity 2: Space Career Scavenger Hunt (30 mins)

1. Working in pairs, ask learners, to complete worksheet: Space Career Challenge Hunt and divide the tasks between them to complete all the challenges.
2. Once completed, have two groups combine and discuss their answers
3. Ask some of the learners to share their challenge findings with the class

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L11 Exploring Space Careers

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete Activity 1 only and complete Activity 2 in a following lesson. Use any remaining time to discuss their findings and any surprising information they found.

Extension: For a longer lesson, invite learners to share any career paths that surprised them and any that inspired or interested them to find out more.

Option B: Invite learners to share their thoughts on how they can apply entrepreneurial principles and STEAM skills to pursue opportunities in the space industry e.g.

- help create new technologies, improve sustainability, or make space tourism more accessible
- apply entrepreneurial strategies to turn an idea in the space industry into a successful venture or project e.g. ways to identify opportunities, attract investors, or develop a business model for a space-related idea.

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

You don't need an Aerodynamics Degree to get into the Space Industry Accessing Space [13:02 mins] https://youtu.be/oF6tV5LeGIc?

European Space Agency Art and Culture in Space and Humanities
https://www.esa.int/About_Us/Art_Culture_in_Space/Space_and_the_humanities

Space Skills Alliance Competencies https://craft.spaceskills.org/
Careers Portal https://careersportal.ie/sectors/subsectors.php?sub_sector=162&sector_id=21

SPIN (Space Placements in Industry) placements https://sa.catapult.org.uk/spin/

Enterprise Ireland Company Directory https://www.enterprise-ireland.com/en/supports/become-more-innovative/space-esa-homepage/esa-directory

Local Trip / Expertise / Additional Work and Assessments

Using the links in the Media Box learners can explore roles and skills for the space industry. Learners can begin to research and share their thoughts on how they might pursue careers or educational pathways in STEM / STEAM fields with a focus on space entrepreneurship.

Virtual visit tourist guide: Learners could search and explore virtual visit e.g. NASA's Johnson Space Center, SpaceX headquarters, or observatories around the world. They can then share what they have found and create a virtual visit tourist guide for other students to visit.

MM4: 11WS EXPLORING SPACE CAREERS CHALLENGE

Activity 1: Generating a Space Tourism Logo

You will complete the following series of challenges to explore career paths, educational requirements, scientific space discoveries and space professionals.

Challenge 1 - Career Paths

1. Identify three different career paths in space exploration using the following resources / from the following list

2. Create a definition for each of their roles based on what they do

Challenge 2 - Educational Requirements

1. For the three career paths you have identified, find three universities/colleges offering programmes that help people become qualified.

Challenge 3 - Discoveries and Breakthroughs

1. **Find one recent breakthrough or development in the space industry and summarise its significance.**

    - Why is this breakthrough important for the future of space exploration or tourism? (Consider how it advances technology, reduces costs, or makes space travel more accessible.)

•

- How does this development impact society or industries on Earth? (Think about new job opportunities, technological spin-offs, or how it might inspire future generations.)
- What challenges does this breakthrough address in space exploration, and how does it help overcome them? (Consider whether it solves issues related to sustainability, safety, or affordability in space travel.)

Challenge 4 - Space Professionals

- **Find and watch a TED talk or interview featuring a professional working in the space industry**

- **Summarise your understanding about what they do .**
  - What is the main role or focus of the professional's work in the space industry?
  - (Consider whether they focus on engineering, research, policy, or another aspect of space exploration.)
  - What challenges do they face in their job, and how do they work to overcome them?
  - (Think about technical, environmental, or ethical issues they address in their role.)
  - How does their work contribute to the overall goals of space exploration or space tourism?
  - (Consider how their specific work impacts advancements in technology, accessibility, or sustainability in space.)

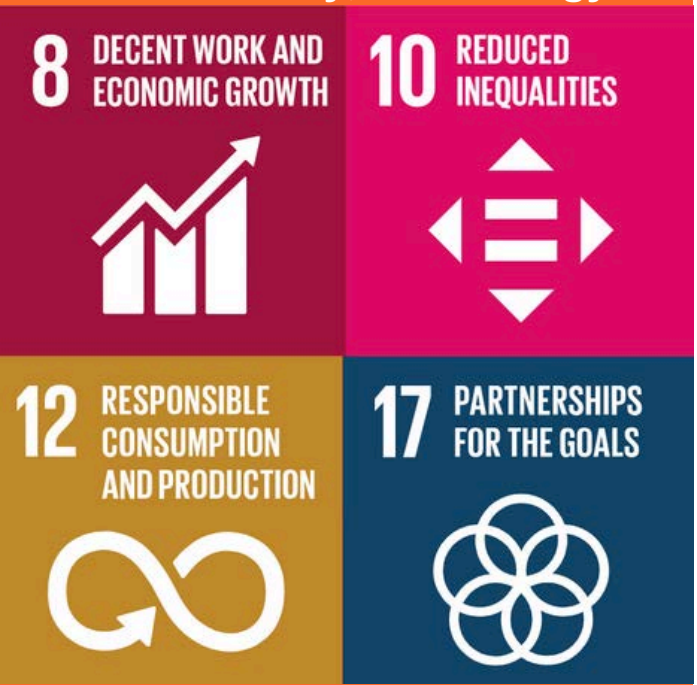
SDG9 Future of Space
MM4:Space Innovation and Enterprise

MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 12 Future Possibilities - Space Industry

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology



Lesson Title and Summary: Future Possibilities - The Space Industry

In this lesson learners will begin to explore the world of entrepreneurship in the space industry, reflecting on their interests, skills, and passions related to space exploration. Through research and exploration, they will identify market needs and opportunities, and create innovative solutions, towards developing clear business ideas to address challenges in the space industry and create their start-up.

Learners will undertake a step-by-step planning for their proposed startup in the space industry, encouraging them to think critically, creatively, and strategically about an entrepreneurial journey.

Vocabulary: Entrepreneur, Innovation, Start-up, Venture

In this lesson, the learner will:

- begin identify personal interests and skills that relate to an area of the space industry and entrepreneurship
- analyse market needs and opportunities by conducting research including trends, challenges, opportunities in the space industry, identifying unmet needs and gaps in the market that their startup ventures could address develop innovative solutions to address identified market needs or challenges in the space industry
- develop a clear business idea outlining their value proposition, target market, and possible funding streams
- think the creativity, innovation, and critical thinking skills necessary for an entrepreneurial journey

Materials

- Worksheet: Considering the possibilities of the future Space Industry
- Worksheet: Start up Space Venture
- Teaching Guide: Setting up a Start-up Hub in a School
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise
L12 Future Possibilities - The Space Industry

Activity Instructions

Activity 1: Considering the possibilities of the future Space Industry (15 mins)

1. Working individually, ask learners to answer the self-assessment questions on worksheet: 'Considering the possibilities of the future Space Industry'.
2. Remind learners to use the Space Skills Alliance - transferable skills list to consider during their self-assessment
3. Once completed, learners will select up to three areas that interest them from the list of areas in the space industry.
4. Ensure Learners rank these three areas in order of preference 1 - 3 on the worksheet
5. They will try to find another three learners with as close a selection to them as possible, both industry and ranking.
6. These learners will be their start-up business partners for Activity 2

Activity 2: Start up Space Venture (35 mins)

1. Working in teams of four, with their start-up business partners from Activity 1 (step 5 and 6), using Worksheet: Future Space Venture.
2. They will begin by considering their self-assessment skills and passions to assign key roles in the team.
3. Based on their roles and selected space industry sector they will divide the step-by-step questions to help them create the beginnings of their start up.
4. Circulate to encourage learners to explore their answers more thoroughly
5. Depending on time, start-up teams can share their ideas and reflections on the process, e.g.

    - what they found challenging or any insights they gained that are transferable to other roles / parts of their life.

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise
L12 Future Possibilities - The Space Industry

EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson, complete Activity 1 only and complete Activity 2 in a following lesson. Use any remaining time to summarise their process and consider the next stage / prepare for any following lessons.

Extension: For a longer lesson, continue the discussion from the class sharing and invite learners to share their thoughts on how they can apply entrepreneurial principles and STEAM skills to pursue opportunities in the space industry.

Option B: Learners can develop activity 2 in additional classes. If learners are continuing this activity in follow on lessons, link learners to resources in the Future of Innovation, MM1: Passion to Purpose Module to develop a pitch or explore their market / customers - see linked learning for suggestions and references to other supporting resources.

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Space Skills Alliance - Transferable Skills https://craft.spaceskills.org/themes/Transferable%20skills

Space Skills Alliance https://spaceskills.org/

Space Skills Alliance Census https://spaceskills.org/census-2020-intro The 2020 Space Census was the first national survey of the UK space workforce.

Careers Portal https://careersportal.ie/sectors/subsectors.php?sub_sector=162&sector_id=21

Enterprise Ireland Company Directory https://www.enterprise-ireland.com/en/supports/become-more-innovative/space-esa-homepage/esa-directory

Local Trip / Expertise / Additional Work and Assessments

Start-up hub: The learning from this lesson and the module can continue by creating a start-up hub and having the teams work over a number of lessons to build out their start-ups, support each other by skills sharing or joining other start-ups or collaborating if there are relationships between the sectors.

Activities from the MM1: Future of Innovation: Passion to Purpose Module can be used to support them to do this

Longer term, consider setting up a start-up hub - see teacher's guide, which could support annual projects in Transition Year.

MM4: 12TG SETTING UP A START-UP HUB IN A SCHOOL

Teacher's Guide for Setting Up a Start-Up Hub in a School

Creating a Start-up Hub within a school provides students with a platform to develop entrepreneurial skills, innovate, and turn ideas into real-world ventures. By creating a structured and supportive environment, a school-based Start-up Hub can foster creativity, problem-solving, and entrepreneurial thinking in students, preparing them for future careers and innovations. Below is a guide to help set up and facilitate such a hub.

Define the Vision and Purpose

- Clarify Objectives: Set a clear purpose for the hub (e.g., fostering entrepreneurial skills, promoting innovation, encouraging teamwork).
- Identify Key Focus Areas: Decide if the hub will target specific industries (e.g., technology, social entrepreneurship, environmental innovation).

Secure Support and Resources

- Administrative Buy-In: Get approval and support from school leadership.
- Space and Infrastructure: Allocate a dedicated space within the school for brainstorming, collaboration, and presentations.
- Budget: Establish a small fund for supplies, prototyping, or hosting events.

Create a Curriculum or Framework

- Incorporate STEAM and Business Principles: Integrate Science, Technology, Engineering, Arts, Math (STEAM) alongside entrepreneurial skills like marketing, financial literacy, and project management.
- Workshops and Sessions: Set up weekly or bi-weekly workshops on topics like:
  - Ideation and creativity.
  - Market research.
  - Branding and marketing.
  - Pitching to investors.

Recruit Mentors and Experts

- Industry Experts: Invite local entrepreneurs, alumni, or business professionals to provide mentorship.
- Partnerships: Collaborate with local businesses or startup incubators to provide real-world insights and potential funding.

Encourage Student Participation

- Project-Based Learning: Allow students to form teams, identify problems, and develop solutions that could turn into viable business models.
- Competitions: Host pitch competitions or challenges where students present ideas to a panel of judges (similar to a Dragon's Den format).

MM4: 12TG SETTING UP A START-UP HUB IN A SCHOOL

Develop an Ongoing Support System

- Networking Opportunities: Organise field trips to start-up incubators or tech events. Access to Resources: Provide resources for research, prototyping, and funding (through grants or sponsors).

Assessment and Reflection

- Milestone Reviews: Set checkpoints for students to present progress.
- Reflection: Encourage students to reflect on challenges, solutions, and future plans.

Sample Structure for the Hub

1. Kick-Off Event: Launch the hub with a school-wide event or competition.
2. Weekly Workshops: Each week focuses on a different entrepreneurial skill or startup principle.
3. Mentorship: Monthly check-ins with assigned mentors.
4. Prototype Day: A day where students build and test prototypes of their ideas.
5. Pitch Day: End-of-term presentation where students pitch their startup ideas to a panel of experts.

Key Considerations

- Inclusivity: Ensure students from diverse backgrounds and skill sets feel encouraged to participate.
- Long-Term Impact: Help students see the potential for turning school projects into real-world ventures.
    -

MM4: 12WS CONSIDERING THE POSSIBILITIES OF THE FUTURE SPACE INDUSTRY

Activity 1 Considering the possibilities of the future Space Industry

The future of space exploration holds vast opportunities for careers and business across various disciplines. As technology advances and humanity's presence in space expands, new opportunities will continue to emerge across sectors of the space industry.

First, answer the self- assessment questions below

Self-Assessment:

1. What aspects of space exploration fascinate and excite you the most?

2. Reflecting on your skills and passions, which areas of the space industry do you feel drawn to? (e.g., science, engineering, entrepreneurship)

3. How can you use your interests and talents to contribute meaningfully to the space industry?

4. Think about how you will explore your selected area of the space industry through education, research, networking, and hands-on experiences and see if this appeals to you?

Use the Space Skills Alliance Transferable Skills list to help you in this self-assessment https://craft.spaceskills.org/themes/Transferable%20skills

Below are just a few examples of the diverse and exciting career / ventures possibilities that the future of space exploration holds. Select one of the Future Possibilities within Space Exploration that interests you most. This will be the focus of your new venture.

MM4: 12WS CONSIDERING THE POSSIBILITIES OF THE FUTURE SPACE INDUSTRY

- Space Mining: As technology advances, space mining could become a reality, leading to opportunities for careers in asteroid mining, resource extraction, and space resource utilisation. Professionals in this field may include geologists, mining engineers, roboticists, and space resource specialists.
- Space Colonisation: Establishing permanent human settlements on other planets, such as Mars, presents numerous career opportunities in fields like aerospace engineering, habitat design, life support systems, agriculture, and medicine. Careers in space colonisation may involve roles in research,architecture, design, construction, logistics, and governance.
- Space Manufacturing: In-space manufacturing, utilising resources found in space to produce goods, holds potential for reducing the costs of space exploration and enabling long-duration missions. Careers in space manufacturing may include materials scientists, engineers, 3D printing specialists, and robotics experts.
- Space Science and Exploration: Advancements in space telescopes, probes, and robotic missions offer opportunities for careers in space science and exploration. Professionals in this field may study planets, moons, asteroids, and other celestial bodies to understand their composition, origins, and potential for supporting life.
- Space Medicine and Health: With the increasing duration of space missions and plans for long-term space habitation, there's a growing need for professionals in space medicine and health. Careers in this field may involve researching the effects of microgravity on the human body, developing medical technologies for space travel, and providing healthcare for astronauts.
- Space Law and Policy: As commercial space activities expand, there's a need for legal and policy experts to navigate issues related to space governance, property rights, liability, and international cooperation. Careers in space law and policy may include space lawyers, policymakers, diplomats, and regulatory specialists.
- Space Communications and Navigation: Ensuring reliable communication and navigation systems is crucial for space missions and satellite operations. Careers in space communications and navigation may involve developing satellite networks, ground control systems, and deep space communication protocols.
- Space Environmentalism: With the growing presence of satellites and space debris in Earth's orbit, there's a need for professionals to address environmental concerns in space. Careers in space environmentalism may include space debris mitigation specialists, satellite tracking experts, and sustainability advocates.
- Space Education and Outreach: As public interest in space exploration grows, there's a demand for educators, communicators, and outreach specialists to inspire and educate the next generation of space enthusiasts. Careers in space education and outreach may involve teaching, science communication, museum curation, and public engagement initiatives.

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Activity 2 Startup Space Venture

You are a serial entrepreneur, someone who starts multiple businesses, often stepping back or selling before starting another 1. You are looking at the Space Industry for your latest venture. Use the supporting resource to consider the future possibilities and select the one that interests you most.

Area of the Space Industry for your Venture :

Type of Role: Who's doing what

Consider the roles involved in a start up and review your skills from worksheet one and see how you can assign roles and divide the tasks to answer the questions. These key roles are the basics for a start up - you will have to share responsibilities as you are only a team of 3 / 4, everyone in the team will share the role of founder / Entrepreneur unless there is an obvious team member for this role - this must be decided by the team.

Founder/Entrepreneur:
Responsibilities: The founder or entrepreneur is the visionary leader of the startup, responsible for coming up with the initial idea, setting the overall direction and strategy, and inspiring others to join the journey. They drive innovation, make critical decisions, and oversee the development and growth of the startup.

Product Manager:
Responsibilities: The product manager is responsible for translating the founder's vision into a tangible product or service. They work closely with the development team to define product requirements, prioritize features, and ensure that the product meets the needs of the target market. They also gather feedback from users and iterate on the product to improve its usability and functionality.

Marketing and Communications Specialist:
Responsibilities: The marketing and communications specialist is responsible for promoting the startup's product or service to the target audience. They develop marketing strategies, create compelling content, and execute campaigns across various channels such as social media, email, and events. They also engage with customers, build brand awareness, and communicate the value proposition of the startup to the market.

Technical Lead/Chief Technology Officer (CTO):

Responsibilities: The technical lead or CTO is responsible for overseeing the technical aspects of the startup, including software development, hardware implementation, and technological infrastructure. They lead the technical team, make decisions regarding technology stack and architecture, and ensure that the product is built using best practices and cutting-edge technologies. They also collaborate with other team members to align technical solutions with the overall business strategy and goal

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Operations Manager:

Responsibilities: The operations manager is responsible for managing the day-to-day operations of the startup, ensuring that processes run smoothly and efficiently. They oversee administrative tasks, coordinate logistics, and manage resources such as finances, facilities, and human resources. They also identify areas for improvement and implement solutions to optimize operational efficiency, enabling the startup to scale and grow effectively.

Part 2 Complete the Questions to help you plan your new Space Venture

Once your roles are decided and areas of responsibility divide the questions between the team and work through the ones you are responsible for. You should allow time to share your answers with your start-up business partner to get feedback / more ideas.

Identify Market Needs and Opportunities:

1. What are the current trends and emerging technologies in the space industry?
2. Are there any specific challenges or unmet needs in the space market that your startup could address?
3. How can you conduct market research to gain insights into potential opportunities and gaps in the space industry?
4. Who are the key players and stakeholders in the space market, and how can you learn from their experiences and perspectives?

Problem-Solving and Innovation:

1. What innovative solutions can you brainstorm to address the identified market needs or challenges in the space industry?
2. How can you apply your skills and knowledge to create value and make a positive impact in the space market?
3. What unconventional approaches or out-of-the-box ideas can you explore to solve problems in the space industry?
4. How can you foster a culture of creativity and innovation within your startup team?

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What will your startup focus on:

1. What specific problem or opportunity will your startup address in the space industry?
2. Who are your target customers or stakeholders, and what are their needs and pain points?
3. What unique value proposition does your startup offer, and how does it differentiate from existing solutions?
4. How will you monetise your business idea and generate revenue streams in the space market?

Build a Network and Seek Mentorship:

1. Who are the professionals, experts, and mentors in the space industry that you admire and respect?
2. How can you connect with them through networking events, industry conferences, or online communities?
3. What questions or challenges do you have that could benefit from the insights and guidance of experienced mentors?
4. How can you build and nurture relationships with mentors who can provide valuable advice and support throughout your entrepreneurial journey?

Acquire Relevant Skills and Knowledge:

1. What specific skills and knowledge are essential for success in the space industry and entrepreneurship?
2. How can you continuously learn and acquire these skills e.g. courses, workshops, or hands-on experiences?
3. What resources and learning opportunities are available to help you develop your entrepreneurial skills and expertise?
4. How can you leverage your strengths and talents while also building new skills to adapt to the dynamic nature of the space industry?

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Prototype and Test:

- What features or functionalities will your prototype or MVP (Minimum Viable Product) have to address the identified market needs?
- How can you design and develop a prototype that effectively demonstrates the value proposition of your startup to potential customers or stakeholders?
- What feedback mechanisms and testing methods will you use to gather feedback and validate your assumptions about your startup idea?
- How will you iterate and refine your prototype based on the feedback received to ensure that it meets the needs and expectations of your target market?

Secure Funding and Resources:

1. What are the different funding options available to support your startup in the space industry (e.g., grants, investors, crowdfunding)?
2. How can you prepare a compelling pitch or business plan to attract potential investors or funders to support your startup?
3. What resources and support services are available through incubators, accelerators, or co-working spaces to help you launch and grow your startup?
4. How can you leverage your network and connections to access funding and resources that will enable your startup to succeed in the competitive space market?

Execute and Iterate:

1. What specific action steps will you take to execute your business plan and launch your startup in the space industry?
2. How will you measure and track the progress and performance of your startup against your goals and milestones?
3. What strategies and mechanisms will you implement to gather feedback from customers and stakeholders and iterate on your product or service?
4. How will you adapt and pivot your startup based on the lessons learned and insights gained from your experiences in the space market?