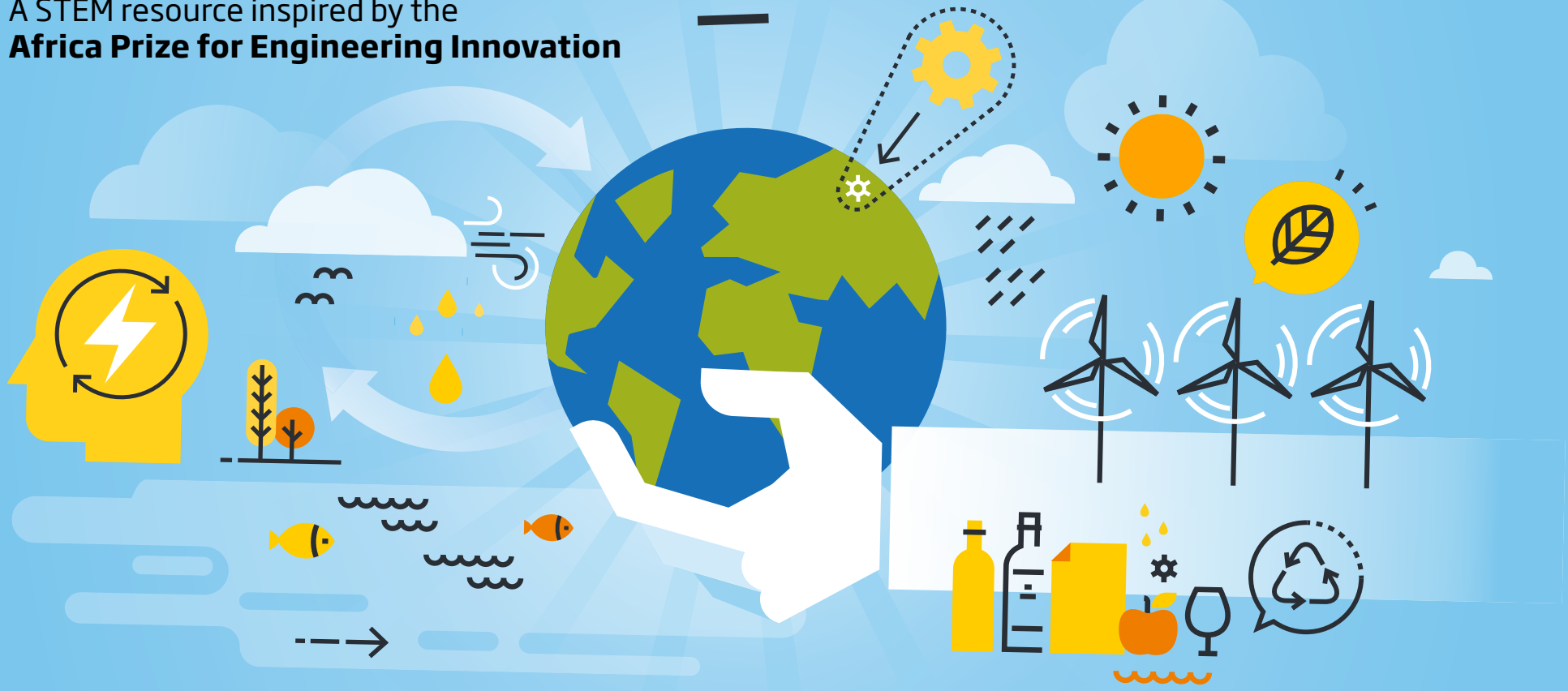
ENGINEERING A BETTER WORLD

A STEM resource inspired by the
Africa Prize for Engineering Innovation



ROYAL ACADEMY OF ENGINEERING

The Shell Centenary Scholarship Fund

GCRF
Global Challenges Research Fund

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Tell us what you think of this resource!

Take our short survey for a chance **to win £500** of robotics/coding equipment for your school.

Scan this QR code on your phone or go to http://stemresources.raeng.org.uk/teacher-survey/

AFRICA PRIZE ACTIVITIES – TEACHER NOTES

The Africa Prize resource box is a series of activities, practical tasks and discussion points that invite young learners to explore the role that young engineers and entrepreneurs play in developing innovations that will bring social and environmental benefits to different countries across sub-Saharan Africa.

The resource box pulls together science, technology, engineering and maths (STEM) subjects through thematic learning and collaborative activities. It has been designed to provide practical and contextualised applications to demonstrate the role that STEM-based learning plays in global real-world engineering scenarios.

Background on the Africa Prize for Engineering Innovation

The Africa Prize for Engineering Innovation, launched in 2014, encourages ambitious and talented sub-Saharan African engineers from all disciplines to apply their skills to develop scalable solutions to local challenges, highlighting the importance of engineering in improving quality of life and economic development.

The prize aims to stimulate, celebrate and reward engineering innovation and entrepreneurship in sub-Saharan Africa.

The Africa Prize for Engineering Innovation:

- promotes engineering and innovation as a tool for development and socio-economic growth
- highlights inspiring engineering role models on the African continent
- encourages young people to study engineering and become engineers.

A selection of prize winners and participants have been chosen to create this learning resource.

Find out more information about the Africa Prize for Engineering Innovation here.

HOW TO USE THIS RESOURCE

This resource is divided into three main sections:

1 Setting the scene

These are tasks, activities and discussion points that provide context and background to support young learners' understanding of the physical characteristics of Africa, and background on the Africa Prize for Engineering Innovation and the Sustainable Development Goals (SDGs).

As part of the Africa Prize, each of the engineering entrepreneurs demonstrates how their innovation meets one or more of the 17 SDGs as set out by the United Nations in 2015, these have been included as a running theme throughout the resource. More information about the SDGs and ideas for activities that could be used to introduce them to learners can be found on page 12.

The starter activities are designed to motivate, engage and raise awareness of the environment in which the core STEM learning tasks are set, as well as continuing to bridge the gap between STEM subjects and other areas of the school curriculum.

2 'In the box' activity sets

The 'in the box' activity sets explore individual Africa Prize innovations in more detail.

The activities are UK curriculum-linked and could be taught as topics as part of timetabled lessons or as enrichment activities.

As each of these activities focuses on an innovation from an engineer and entrepreneur from a specific country, each activity has starter tasks that encourage pupils to develop a stronger understanding of the local environment that the innovation has been designed for.

We suggest you start with the activities in the DEXT Science Set booklet as this will support learners with some of the tasks in the innovator activity sets.

3 World's largest lesson

Inspired by the engineers and entrepreneurs, pupils will work together to plan, design and engineer a product, system or technology that will improve the experiences of those in their community.

They will demonstrate how their innovation works towards one of the SDGs, showing that although their design is for their local community, they are conscious, global citizens.

Once pupils have completed their project, they can share their work with other young people around the world as part of the 'world's largest lesson'.

We suggest that you and your pupils work on this challenge after they have completed a selection of tasks and challenges from the 'in the box' activities mentioned above. The challenge is designed to be carried out over several hours, which could be a whole STEM day or one hour a week over the course of a school term.

Pupils can work towards a CREST award as they journey through this project. More information about the CREST award can be found on page 6.

CURRICULUM LINKS

The activities and challenges bridge several subjects across the curriculum, not just STEM subjects, however for ease of reference, these have been linked to one or two specialisms only.

Age group is also given as a guide and activities can be extended or broken down depending on the group.

More information about the national curriculum in England can be found here.

More information about the Scottish school curriculum can be found here.

More information about the Northern Irish school curriculum can be found here.

At the time of writing, a new school curriculum is being developed for Wales.

More information can be found here.

Activity	Subject	Age group	Curriculum link
Continent and country profiles	*Geography*	7-11	Use maps, atlases, globes and computer mapping to locate countries and describe features.
		9-14	Expand locational knowledge and deepen spatial awareness on Africa focusing on environmental regions, including key physical and human characteristics.
	Maths	7-11	Use percentages, decimals and fractions as different ways of expressing proportion.
		11-14	Round numbers to an appropriate degree of accuracy.
	Science	9-14	Draw on increasing knowledge and understanding to suggest ways in which they can reduce their own energy use and live more sustainably.
SolarKoodo	*Maths*	9-14	Construct and interpret bar charts and pie charts.
	Maths	9-14	Show how quantities that are related can be increased or decreased proportionally.
	Science	9-14	Use a range of electrical components to make a circuit for a specific purpose.
Majik Water	*Science*	7-11	Identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature.
	Maths	7-11	Use the terms profit and make calculations to generate this.
The Vertical Farm	*Science*	9-14	Contribute to experiments and investigations to develop understanding of models of matter.
	Maths	9-14	Calculate volume and surface area of cuboids.
	Design / technology	7-11	Enhance design skills to solve problems and construct models.
Muzikol	*Science*	9-14	Learn about frequencies of sound waves and sound produced by vibrations in objects.
	Maths	7-14	Recognise arithmetic sequences and generalise these sequences.
	Science	9-14	Use a range of electrical components to make a circuit for a specific purpose.
Smart Havens Africa	*Science*	9-14	Use a range of electrical components to make a variety of circuits for differing purposes.
	Science	9-14	Represent my circuit using symbols and describe the transfer of energy around the circuit.
Grand design challenge	*Design / technology*	7-11	Identify and solve own design problems.
		9-14	Develop specifications to inform the design of innovative and functional products.
		11-14	Develop and communicate design ideas through a variety of methods and tools.

ENGINEERING HABITS OF MIND

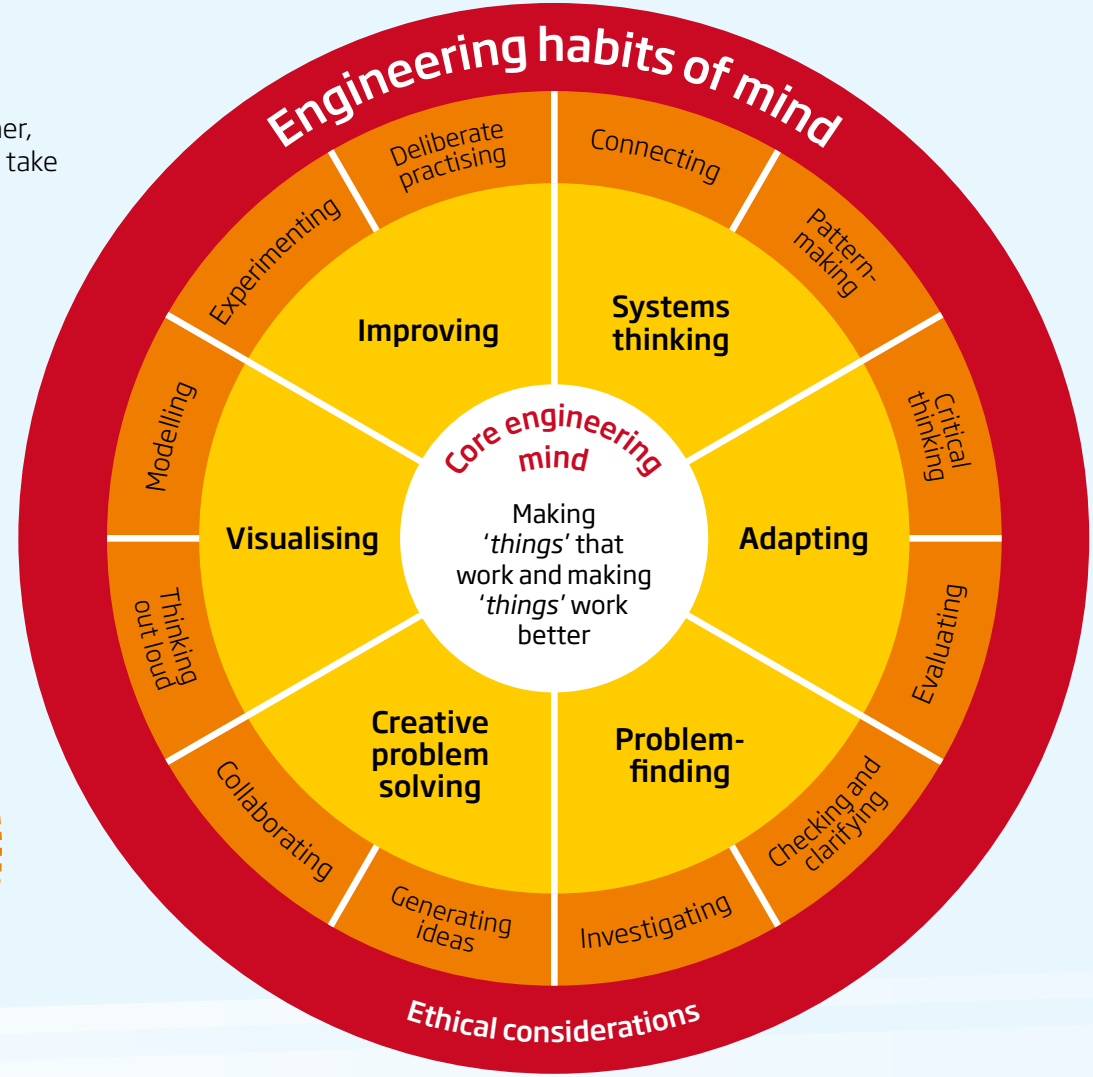
The activities presented in this resource are designed to be interactive, open-ended, encourage discussion and promote the engineering habits of mind (EHoM).

The EHoM encourage the use of a pedagogical approach that cultivates problem-solving skills, creativity, making mistakes, reviewing and planning.

There is no prescriptive teaching method, and it is up to you as a teacher, educator or STEM club leader to decide on which direction you wish to take each activity and where you may wish to spend more time.

We have sign-posted points in the resource where we ask young learners to identify what EHoM they are demonstrating, however we suggest you introduce them at different stages of teaching and learning as you see suitable.

Read the full report 'Thinking like an engineer' here.



DISCOVERY AWARDS

The world's largest lesson is an excellent opportunity for pupils to work towards achieving a Discovery CREST award.

CREST is a nationally recognised scheme for pupil-led project work in STEM subjects. It enables five to 19-year-olds to build skills and demonstrate personal achievement in creative STEM project work that supports their curriculum-based learning.

Discovery Awards offer an introduction to real project work and give pupils the freedom to run their own investigations. They can be completed over the course of a day, or for one hour a week over the course of a school term with pupils working together in self-managed groups.

How to get your CREST Discovery Award

1. Sign-up for a free account at https://my.crestawards.org
2. Download the teacher guide and Discovery Passport
3. Create a project. For example – **Africa Prize: world's largest lesson**
4. Pupils provide details of the project in their passports
5. Upload pupils' names and two or three passports and any accompanying work
6. Assess pupils. Have they:
   a. completed around five hours of work on the project?
   b. participated fully in the project?
   c. reflected on their learning?

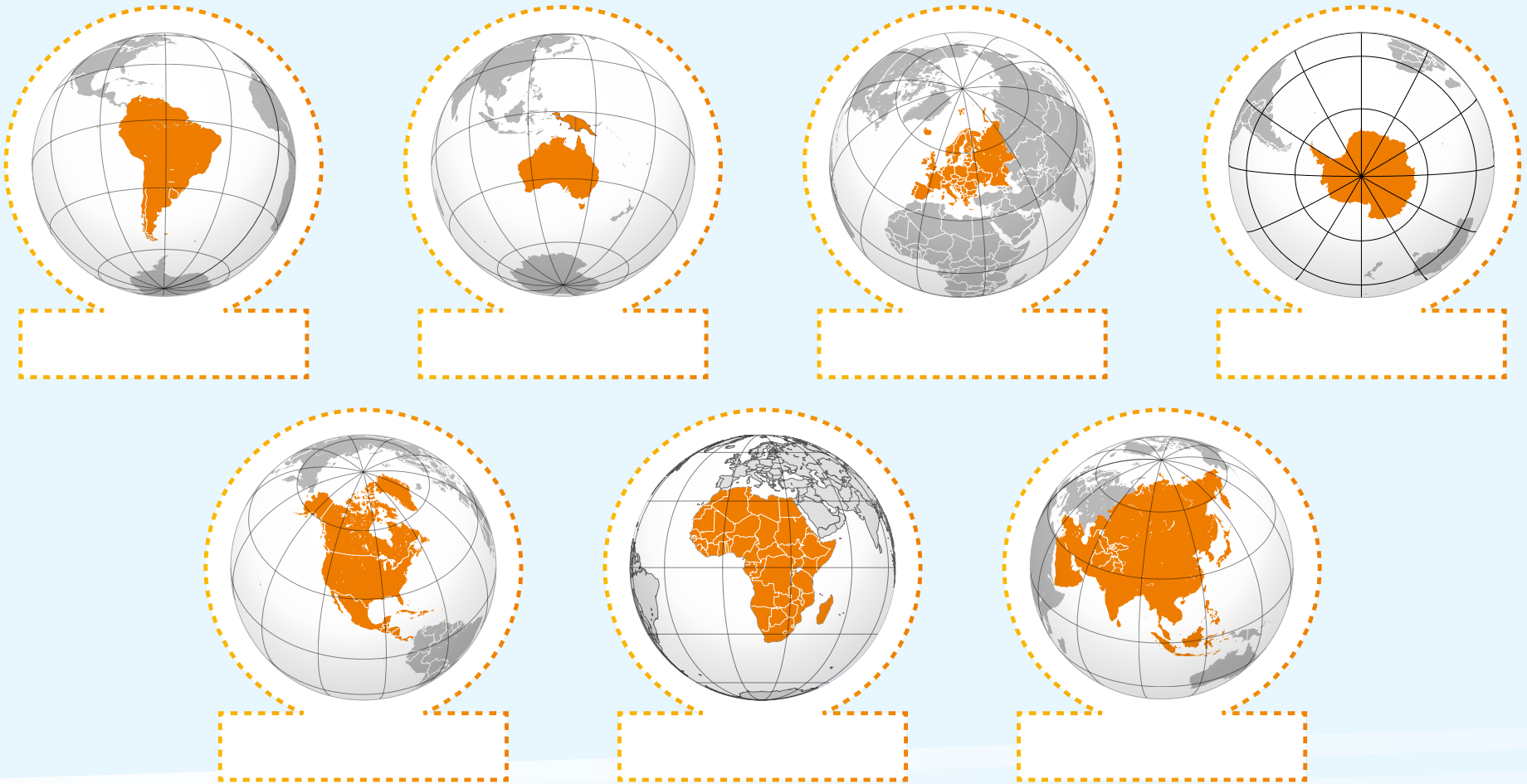
For more information on assessing a CREST Discovery awards visit: http://bsa.sc/assess-discovery

SETTING THE SCENE

Where in the world?

Many engineers get to travel around the world as part of their job and engineers from different countries will often work together.

Can you name the continents? (see next page for names of continents)



Rank the continents

Number of (official) countries

Match the number of countries with the continent.
Rank these in **ascending** (smallest to largest) order.

Antarctica	54 countries
South America	48 countries
Oceania	0 countries
Africa	23 countries
Europe	14 countries
Asia	44 countries
North America	12 countries

Population

The continents have been written in **ascending** population order. The population data is in the wrong order. Match the population to the corresponding continent.

Asia	579,000,000
Africa	1106
Europe	4,436,000,000
North America	38,800,000
South America	1,216,000,000
Oceania	738,000,000
Antarctica	423,000,000

Stretch and challenge

- Write the population of each continent in words (for example, 1,000 in words is one thousand).
- Write the population of each continent to **two significant figures** (for example, 23,540 to two significant figures is 24,000).

*Population data taken from the United Nations, World Population Prospects, 2015 Revision

Rank the continents by area

The area in square kilometres for each continent is given below. Put them in **ascending** order.

Africa	30,000,000km^2
Antarctica	14,000,000km^2
Asia	45,000,000km^2
Oceania	9,000,000km^2
Europe	10,000,000km^2
North America	25,000,000km^2
South America	18,000,000km^2

What do you think would useful ways of presenting the data about population and land area?

Stretch and challenge

Population density compares how many people live somewhere (population) to how much space there is (area).

It tells us how crowded somewhere is (density).

In your groups, think about the town you live in. Do you think it has a high or low population density? Think of other towns or cities you have visited that you think have higher and lower population densities. Explain why you think this to your group.

Population density is measured in people per square kilometre. What is the population density of each continent?

Handy hint!

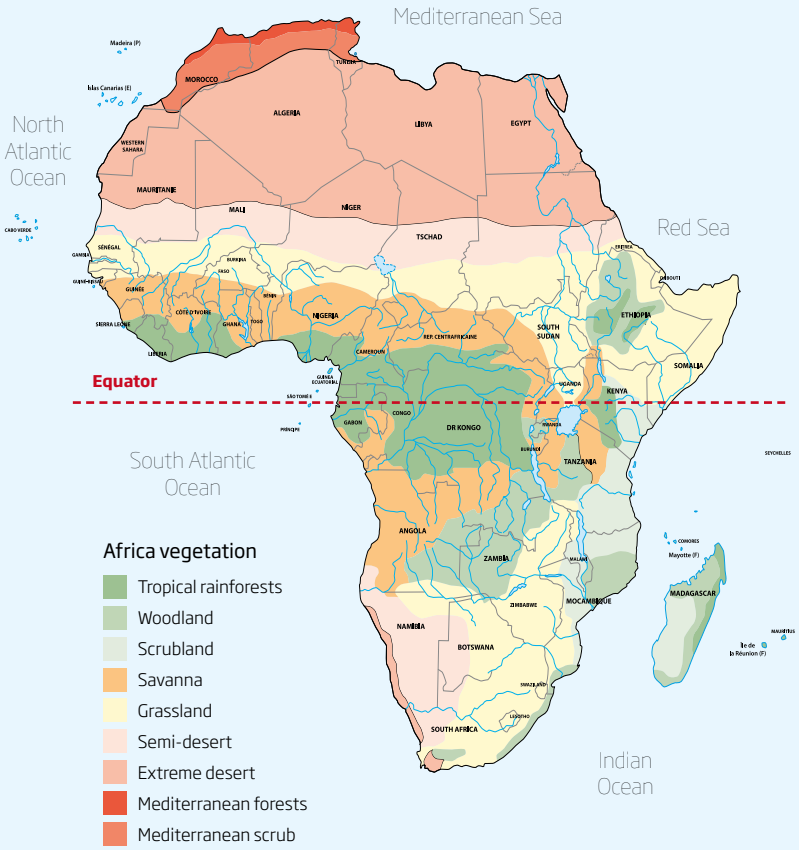
$$\text{Population density} = \frac{\text{Number of people}}{\text{Land area}}$$

RESEARCH TASK: AFRICA – A DIVERSE CONTINENT

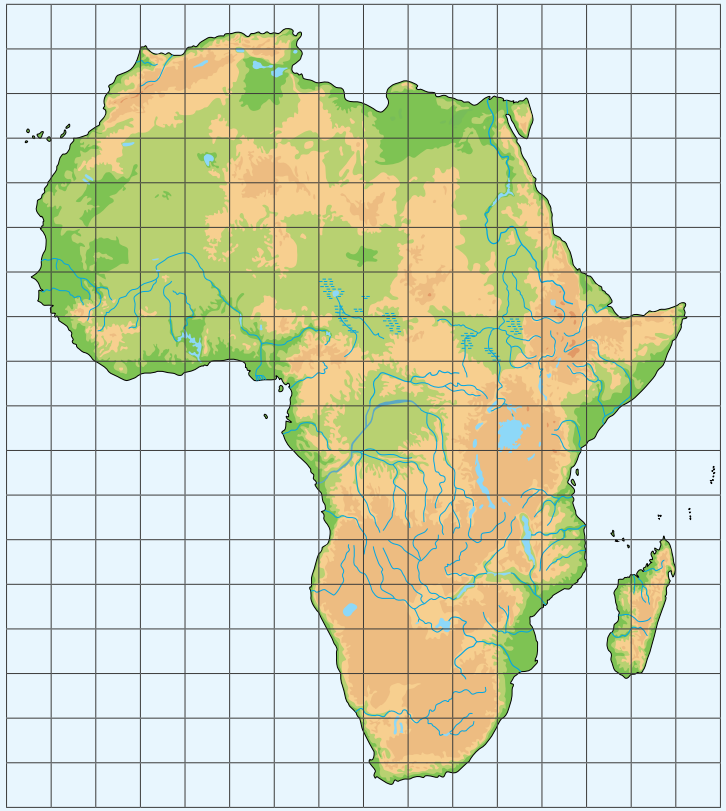
Using the maps shown and a smartphone, tablet, laptop or computer, create a fact sheet answering the following questions.

- What bodies of water does Africa border?
- Name three countries that the equator runs through.
- How many languages are spoken across Africa?
- What is the longest river that runs through Africa?
- Name three countries that are in tropical rainforest, semi-desert and savanna.
- Name three major geographical features. Where are they located in Africa?

Map showing vegetation



Map showing terrain



Africa terrain
- Lowlands
- Mountains

The map of Africa covers approximately 130 squares.

What **proportion** of Africa (as represented in this map) is mountainous, approximately?

Stretch and challenge

- Write the proportion of lowlands and mountains as a fraction in its simplest form, percentage and decimal.

SUSTAINABLE DEVELOPMENT GOALS

The SDGs, otherwise known as the Global Goals, are a set of outcomes to achieve a better and more sustainable future for all.

They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity and peace and justice.

More information about the Global Goals can be found at www.globalgoals.org

Time to think

We have chosen six of the Global Goals for you and your group to investigate.

In your groups, choose one of the six goals selected above and discuss the questions below.

- How do you interpret this goal?
- Why do you think this goal is important?
- How do you think engineering can play a part in achieving this goal?

Present your ideas for each question to the rest of your class.

Teacher note

Another suggestion for this activity is writing one of the six Global Goals mentioned above on a large piece of paper (flipchart size for example) and writing the three questions around the goal.

Carry out the activity as a circuit with each group contributing to each goal.

After a certain amount of time, move the groups around and ask them to continue answering the questions for the new goal, decreasing the amount of time as the activity continues (for example, six minutes, five minutes, four minutes, three minutes, two minutes and finally one minute).

We have selected six SDGs that we thought young learners could most easily identify with, however this is not set in stone and we encourage you to select others that you feel are more suited to those in your class or group.

For more ideas around using the Global Goals in the classroom, **Practical Action** have a great selection of hands-on activities.

Go to www.practicalaction.org/global-goals and take a look at the *String activity*, *Who's responsible* and *Design for a better world*.

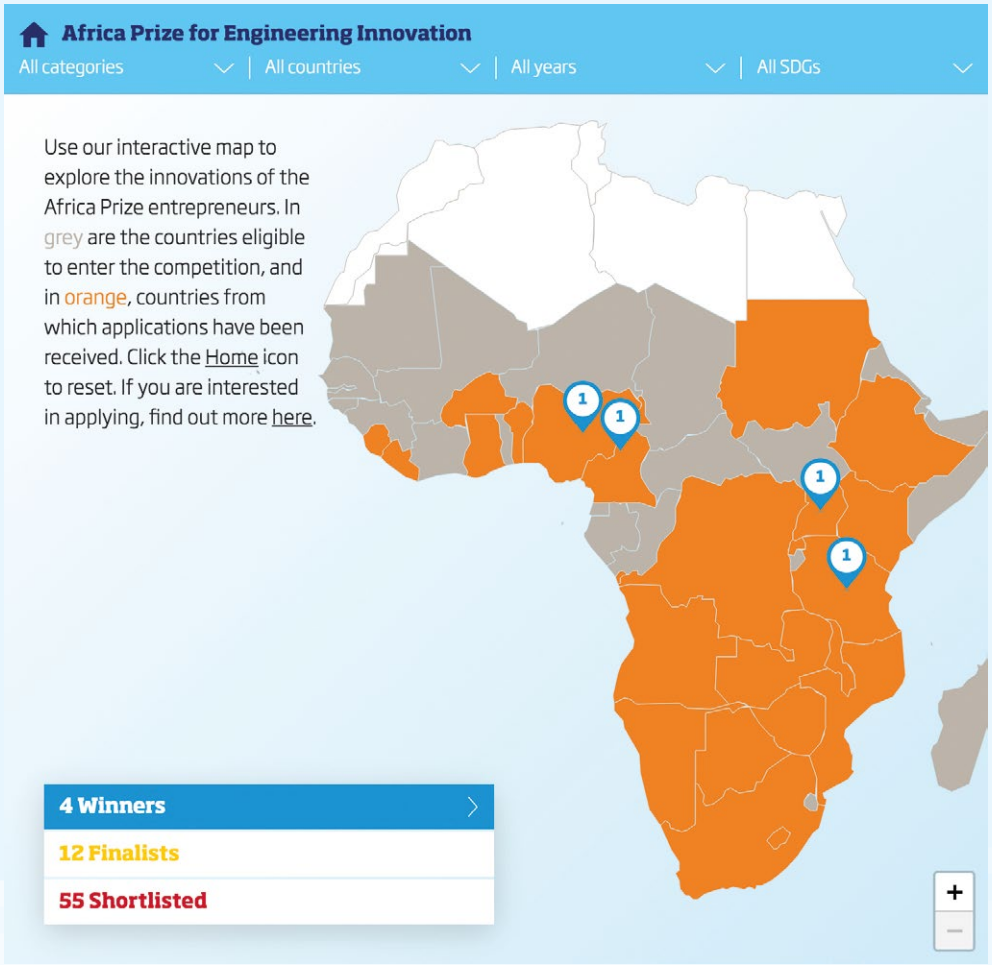
PRACTICAL ACTION
Technology challenging poverty

THE AFRICA PRIZE FOR ENGINEERING INNOVATION

The Africa Prize for Engineering Innovation encourages ambitious and talented sub-Saharan African engineers with different areas of expertise to apply their skills to develop solutions to local challenges. The prize highlights how engineering plays a huge part in improving quality of life and economic development.

Using a smartphone, tablet, laptop or computer, search for the 'Africa Prize Interactive Map' and use the map to answer the questions below.

- Which countries are the prize winners from?
- Which country has the most shortlisted engineers?
- Using the drop-down menu on the far right of the map, choose two of the five goals listed and tell us about an innovation that works towards:
  - Sustainable Development Goal 3: Good health and well-being
  - Sustainable Development Goal 4: Quality education
  - Sustainable Development Goal 7: Affordable and clean energy
  - Sustainable Development Goal 11: Sustainable cities and communities
  - Sustainable Development Goal 12: Responsible consumption and production



BE PART OF THE WORLD'S LARGEST LESSON

Each of the innovators has identified a problem within their community and come up with a creative solution that improves the lives of those around them.

Now it's your turn!

Watch the video showing part three of the world's largest lesson and answer the following questions:

- What are you like as a person?
- What three things are important to you?
- Name two things that are important to your community.
- What small changes could you make to improve something for your community?

*To find the video, using an online search engine, search for 'world's largest lesson part 3'.

A community is a group of people living or working in the same area. People in communities might go to the same schools, shop in the same stores and have similar hobbies. A community could be your family, your friends or your classmates.

What communities are you part of?

Use the six Global Goals from the starter activity as inspiration for your own innovation for your community.

Working in small groups, use your engineering skills to design and build a product or service that will improve the life and wellbeing of those in your community and the environment around them (for example, your family, friends, classmates, teachers or a club you are part of).

You could improve an existing product or service or think up something completely new!

Questions to think about:

- What is the problem you have identified?
- Which Global Goal are you tackling?
- What research might you need to carry out? Who do you need to speak to?
- What is your innovation? How will it help solve the problem?
- Who will benefit?
- How does it impact the environment?
- What materials will it need?

What to present:

- What your project hopes to achieve.
- Who is in your team? What role does everyone have? Use the group work role cards on page 18 provided by your teacher.
- Justify how your project will be beneficial to your school or community.
- Show how your innovation works towards your chosen Global Goal.
- Complete the 'impact' diagram on page 19 showing that you have thought about the impact on different groups and how they will be affected.
- Build a prototype of your innovation using recycled material, clay or dough and/or using the physical components provided 'in the box'.

Time to tinker

- Creating your prototype is an excellent opportunity for you to tinker! Experiment with different materials, structures, design models. This is your chance to test, review and improve!

What is a prototype?

A **prototype** is an early sample, model, or release of a product built to test a concept or process. They act as something to be replicated or learned from.

Computer design time

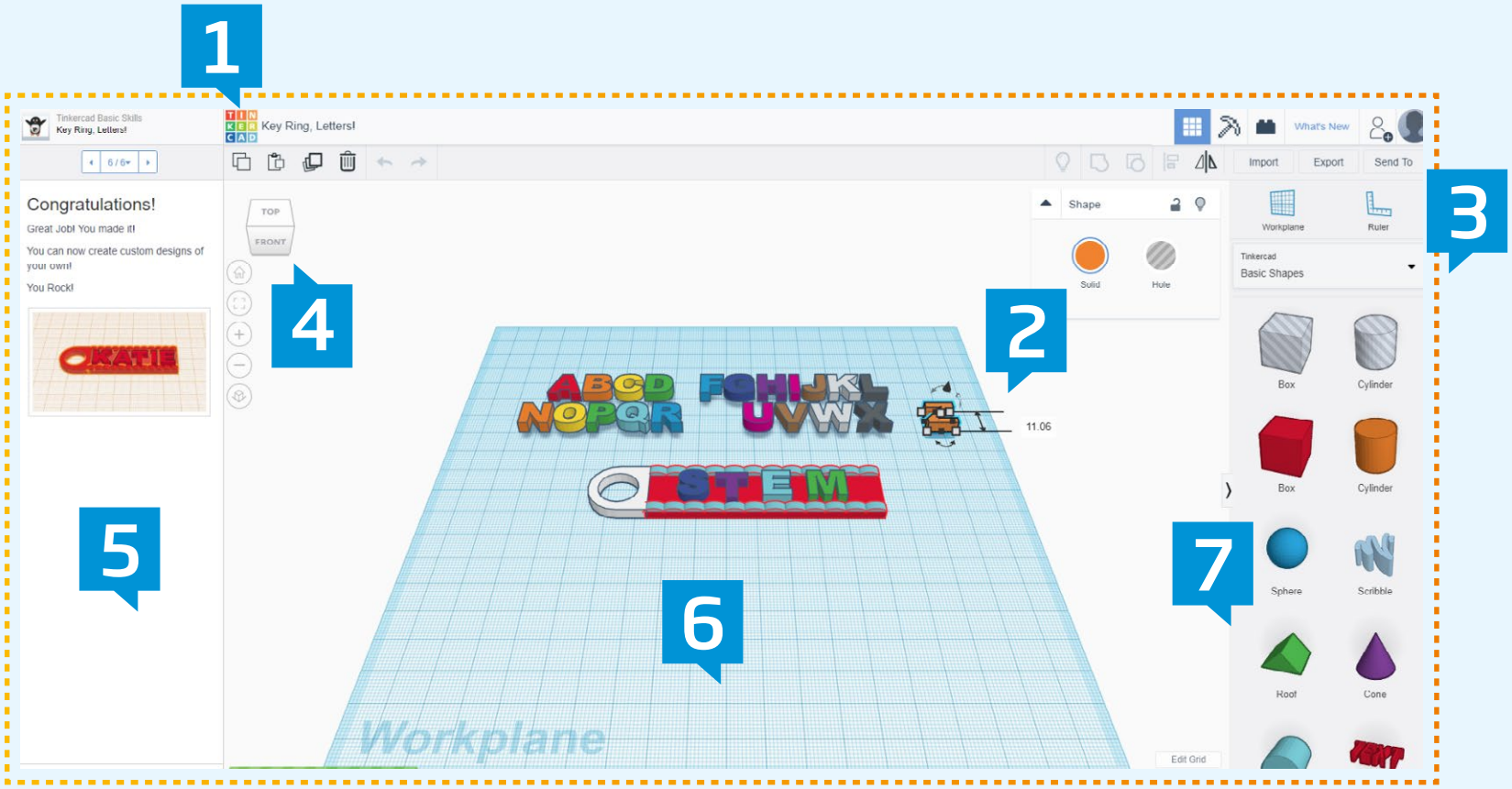
One way to design and create a prototype is using computer aided design (CAD). Have a go at using the free CAD software '**Tinkercad'** (or any other software your school might already use!) to build your prototype.

To use 'tinkercad':

- Go to **www.tinkercad.com**
- Select your privacy and data sharing settings (Tinkercad will work if you select 'No').
- Click on 'Join now' on the top right-hand corner of the page.
- You will now need to ask your teacher or STEM club leader to help you set up an account.
- You're ready to start tinkering!

Teachers note

Each pupil can create their own account but they will need to use the email of a parent or guardian.



1. This will take you to your Tinker dashboard where you can view saved projects and create new projects. You can also find more tutorials by selecting 'Learn' in the top bar on your homepage.
2. Change the dimensions of your shape on your work plane.
3. Toggle between the different shapes available on Tinkercad.
4. Use the cube to change the orientation of your work plane.
5. Step-by-step guide will show here for 'basic skills' lessons.
6. This is your work plane and where you can start building!
7. Drag and drop the different objects from here onto your work plane. Feeling extra creative? Try the 'Scribble' shape.

Group work role cards

Leader

You are responsible for:

- Making sure everyone does their job and helps.
- Making sure the group completes the task on time.

Recorder

You are responsible for:

- Making notes about what the group does and decides.

Innovator

You are responsible for:

- Thinking up ideas to help the group solve problems.
- Explaining your ideas to the group.

Challenger

You are responsible for:

- Trying to think of what might go wrong and encouraging solutions from your team.

Designer

You are responsible for:

- Creating clear designs that communicate your group's idea.

Coach

You are responsible for:

- Finding ways to encourage others.
- Making sure everyone works well together.

Technician

You are responsible for:

- Looking after the tools and materials.
- Making sure everyone has the tools and materials to do their job.

Product developer

You are responsible for:

- Building the model/prototype of your group's product/service.
- Checking with the group that you are making what is needed.

Checker

You are responsible for:

- Looking out for who has too much to do and offering help.
- Telling the leader who you have decided to help.

Reporter

You are responsible for:

- Collecting and preparing material so that it is ready to present to other groups.

Teachers note

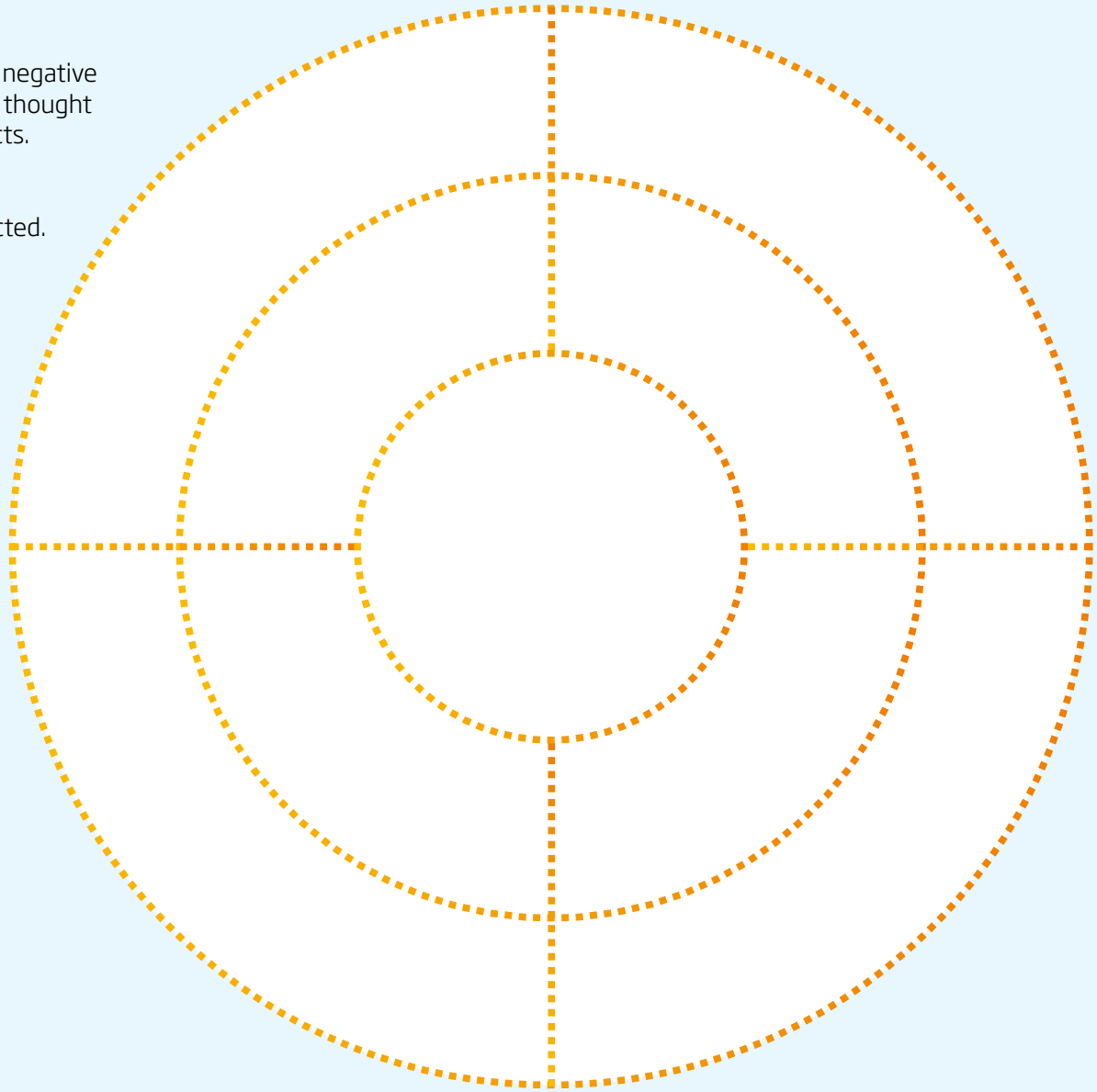
We suggest keeping groups to five or fewer. Each member in the group can have more than one role and set of responsibilities. Young learners could be tasked with prioritising which roles are the most important for their project before selecting their roles.

Encourage groups to switch roles after a certain amount of time working on the world's largest lesson activity.

What's the impact?

In any project there are always risks to consider and possible negative impacts. Complete the diagram below to show that you have thought about these and how you could minimise any negative impacts.

1. Write down your innovation in the centre of the circle.
2. In the middle layer, write down who or what may be affected.
3. In the outer ring, write down how the group will be affected.
4. Colour code the sections to highlight a positive or negative impact.



Time to reflect

The world's largest lesson task is an excellent example of how you have been using your engineering habits of mind. You have been making 'things' that work and making 'things' work better!

Complete the sentences to show how you have been thinking like an engineer.

- I have been problem-finding...
- I have been creative problem-solving...
- I have been visualising...
- I have been adapting...
- I have been systems-thinking (seeing connections and patterns)...
- I have been improving...

Be part of the story!

Children and young people all around the world have been working hard designing, creating, making, helping and spreading the message about the Global Goals.

Once you and your group have completed designing and creating a model of your innovation for the 'world's largest lesson', ask your teacher or STEM leader to add your project to the map.

Become part of the story –
https://worldslargestlesson.globalgoals.org/map

Students
Tell us what you think of this resource!

Take our short survey for a chance **to win £500** of robotics/coding equipment for your school.

Scan this QR code on your phone or go to http://stemresources.raeng.org.uk/student-survey/

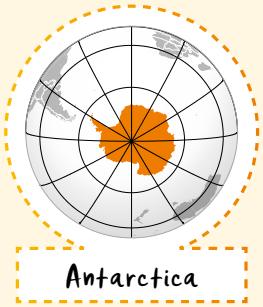
SOLUTIONS – SETTING THE SCENE

Where in the world? Name the continents


South America


Oceania


Europe


Antarctica


North America


Africa


Asia

All map images courtesy of Wikpedia

South America
https://commons.wikimedia.org/w/index.php?curid=7197999

Oceania
https://commons.wikimedia.org/w/index.php?curid=8727360

Europe
https://commons.wikimedia.org/w/index.php?curid=40958608

Antarctica
https://commons.wikimedia.org/w/index.php?curid=7275830

North America
https://commons.wikimedia.org/w/index.php?curid=7072024

Africa
https://commons.wikimedia.org/w/index.php?curid=7121081

Asia
https://commons.wikimedia.org/w/index.php?curid=6234641

Rank the continents

Number of (official) countries

1	Africa	54 countries
2	Asia	48 countries
3	Europe	44 countries
4	North America	23 countries
5	Oceania	14 countries
6	South America	12 countries
7	Antarctica	0 countries

Population

*Population data taken from the United Nations, World Populations Prospects, 2015 Revision

Asia	4,436,000,000
Africa	1,216,000,000
Europe	738,000,000
North America	579,000,000
South America	423,000,000
Oceania	38,800,000
Antarctica	1106

Area

The area in square kilometres for each continent is given below. Put them in **ascending** order.

1	Asia	45,000,000km^2
2	Africa	30,000,000km^2
3	North America	25,000,000km^2
4	South America	18,000,000km^2
5	Antarctica	14,000,000km^2
6	Europe	10,000,000km^2
7	Oceania	9,000,000km^2

What is the population density of each continent?

Asia = 99 people per square kilometre
Africa = 41 people per square kilometre
North America = 23 people per square kilometre
South America = 24 people per square kilometre
Antarctica = 0 people per square kilometre
Europe = 74 people per square kilometre
Oceania = 4 people per square kilometre

SOLUTIONS – AFRICA RESEARCH TASK

- What bodies of water does Africa border?

  Indian Ocean, South Atlantic Ocean, Red Sea and Mediterranean Sea

- What is the longest river that runs through Africa?

  The Nile

- Name three countries that the equator runs through.

  São Tomé and Príncipe, Gabon, Republic of Congo, the Democratic Republic of Congo, Uganda, Kenya and Somalia.

- Name three geographical features. Where are they located in Africa?

  Examples could include the Sahara, the Nile, Mount Kilimanjaro, Atlas Mountains, Suez Canal, Lake Victoria or Victoria Falls (there are many others, which you may wish to research in more details with your pupils).

- How many languages are spoken across Africa?

  Approximately 2000, but most likely many more!

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Royal Academy of Engineering

As the UK's national academy for engineering and technology, we bring together the most successful and talented engineers from academia and business – our Fellows – to advance and promote excellence in engineering for the benefit of society.

We harness their experience and expertise to provide independent advice to government, to deliver programmes that help exceptional engineering researchers and innovators realise their potential, to engage the public with engineering and to provide leadership for the profession.

We have three strategic priorities:

- Make the UK the leading nation for engineering innovation and businesses
- Address the engineering skills and diversity challenge
- Position engineering at the heart of society

We bring together engineers, policymakers, entrepreneurs, business leaders, academics, educators and the public in pursuit of these goals.

Engineering is a global profession, so we work with partners across the world to advance engineering's contribution to society on an international, as well as a national scale.

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