July 2021

Sustainable impact by design

Introduction

"Sustainability means that things will stay the same in the future."

2021 is the year of COP26, (the 26th Conference of the Parties who signed an agreement to work to prevent climate change back in 1994). To mark this, the University of Strathclyde offered funds to staff that would let them talk to people about their research and how it can limit climate change. The STEM Equals Summer Scheme won funding, and so ten Strathclyde staff members were able to work with diverse young people in Ayr and Girvan over five days of STEM[1] activities. This book shows some of the activities we did together, and some of the learning about their planet and sustainability that went on. As you will see in its pages, everyone involved, staff and participants alike, had a lot of fun. We also found out many new things about ourselves, our colleagues, about STEM and about our environment. We hope that everyone who reads our book will enjoy seeing what took place as much as we enjoyed taking part!

Dr Jane Essex
STEM Equals project leader
August 2021

[1]STEM is short for Science, Technology, Engineering and Mathematics)

Storytelling

Allison Galbraith
Storyteller

Allison told stories for each of the days, with a unique character for each of the spheres: Lithosphere, Atmosphere, Hydrosphere and Biosphere.

Lithosphere

> The lithosphere means all the rocks on planet Earth.

My activities involved building stone and its weathering process, through a series of small experiments to guide the students in the learning process. We started talking about rocks. I then showed them some stones that were used in the past to build important monuments around Europe, as York Minster in England and Bern Cathedral in Switzerland. I invited them to observe the stones with the aid of a digital microscope. They could easily see the grains forming the sandstone, and compare them to the grains of the sand I handed them.

I showed some pictures of the monuments that were built with the stones they had just observed under the microscope, and asked them to match the sample with the building based on their colour. My research subject involves the stone degradation process, so I took other pictures revealing some details of the same buildings, from which they could see how badly decayed they are today.

It was then time to demonstrate how the weathering process caused by rain works. We took some pieces of stone used to build Bern Cathedral and dropped them into sample tubes, along with some water. By shaking the tubes, they could see the sand particles detaching from the stone and accumulating on the bottom. At the end, we all moved outside, were they could see the effects of erosion in person, on Dolphin House.

Today, the construction sector represents one of the main contributors to the carbon global emissions. This is why conserving existing buildings is so important, because it represents the way towards a more sustainable future.

Noemi Giovelli
Architectural Design for the Conservation of Built Heritage

How sustainable is stone?

Noemi Giovelli
Architectural Design for the
Conservation of Built Heritage

Solar Cells

Dr. Aruna Ivaturi
Pure and Applied Chemistry

This is so cool. I can't believe we're actually doing real science!

Fraser

Aruna's work looks at how we can make better solar panels, which will let us make electricity without burning fuel. She showed us how to use juice from berries to make solar cells and, to our surprise, they worked!

Solar cells, wind turbines and water turbines are all made from materials that we get from rocks. But we can’t keep digging up more rocks for ever, they will run out in the end.

Managing electricity

We made solar cells on a very sunny day. But it isn't always sunny, sometimes it is dark or windy or rainy. We can make electricity using wind power and water power too. Hong showed us how to make circuits that would control the electricity made in different ways, so that we always have electricity when we want it.

Dr. Hong Yue
Electronic and Electrical Engineering

I was at Dolphin House on the first day of the event, on the 1st of July 2021, and travelled together with Dr Aruna Ivaturi. It was a sunny day, everything was bright and enjoyable.
My 'education session' was on renewable energy. To bring this huge topic closer to Scotland, we talked about the rich renewable resources in Scotland and the nearby sea area. In addition to the presentation session, students also enjoyed the questions and answer part.
It is apparent that all the students know that we can get energy out of the air (wind), the sea (wave and tidal) and the sky (solar). With Will's help, we went through an exciting hands-on session – using a kit called 'Wind Energy for Kids' to explore the wind energy generation with a humble tool. Many thanks to the help of Will, who learned everything very quickly and managed to run the kit properly. One bonus for me – on the return train journey, Aruna taught me a lot about solar energy, very interesting. At the end of day, I'm the one who became less alien to renewable energy.

Dr Hong Yue

Princess Lithosphere's West Tower

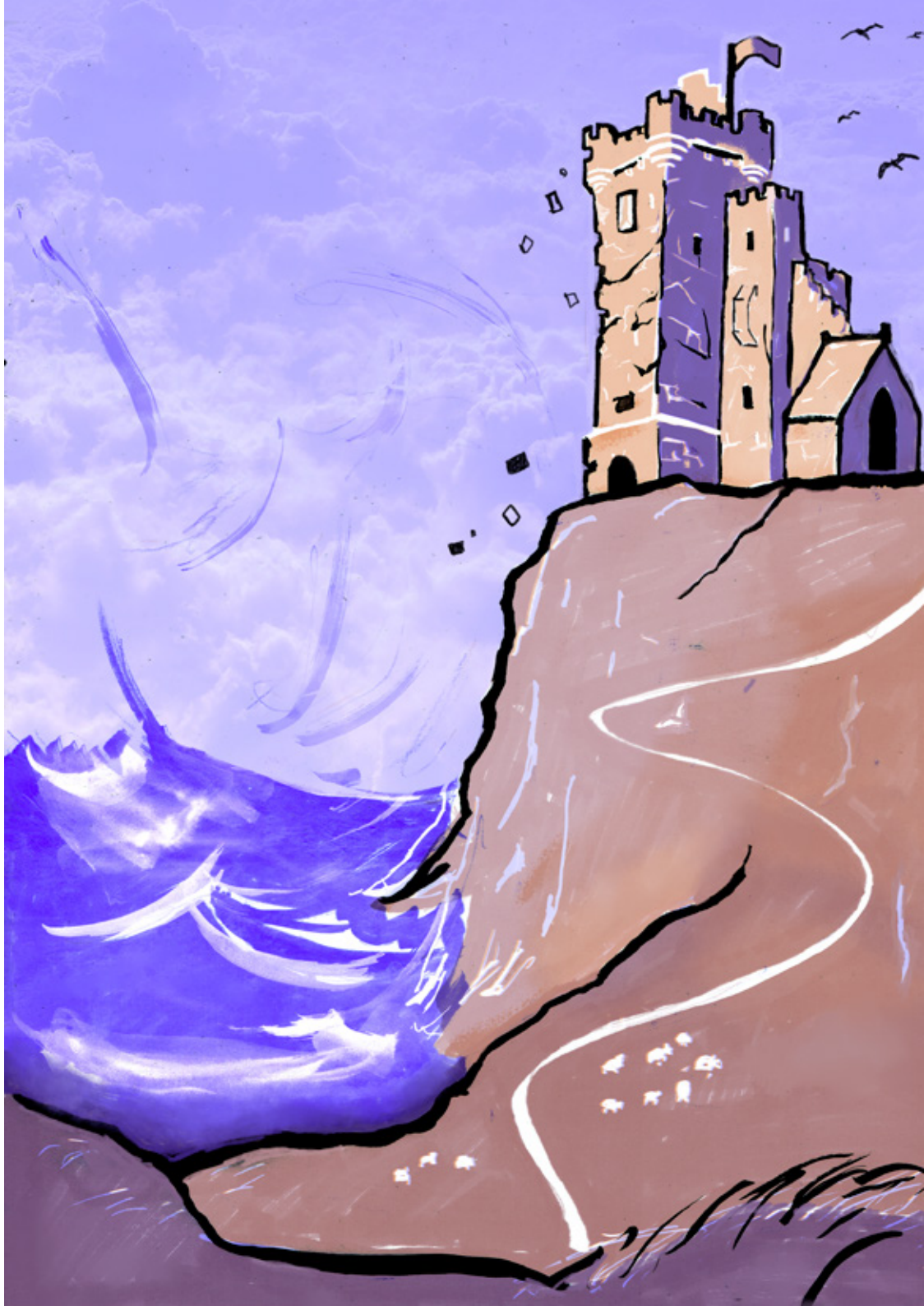
On her fourteenth birthday, Princess Lithosphere was given the best present she could have wished for - her parents gifted her the West Tower of their castle.

Ever since she had been old enough to walk, the princess had been fascinated by the rocks, shells and fossils which surrounded their Ayrshire home.

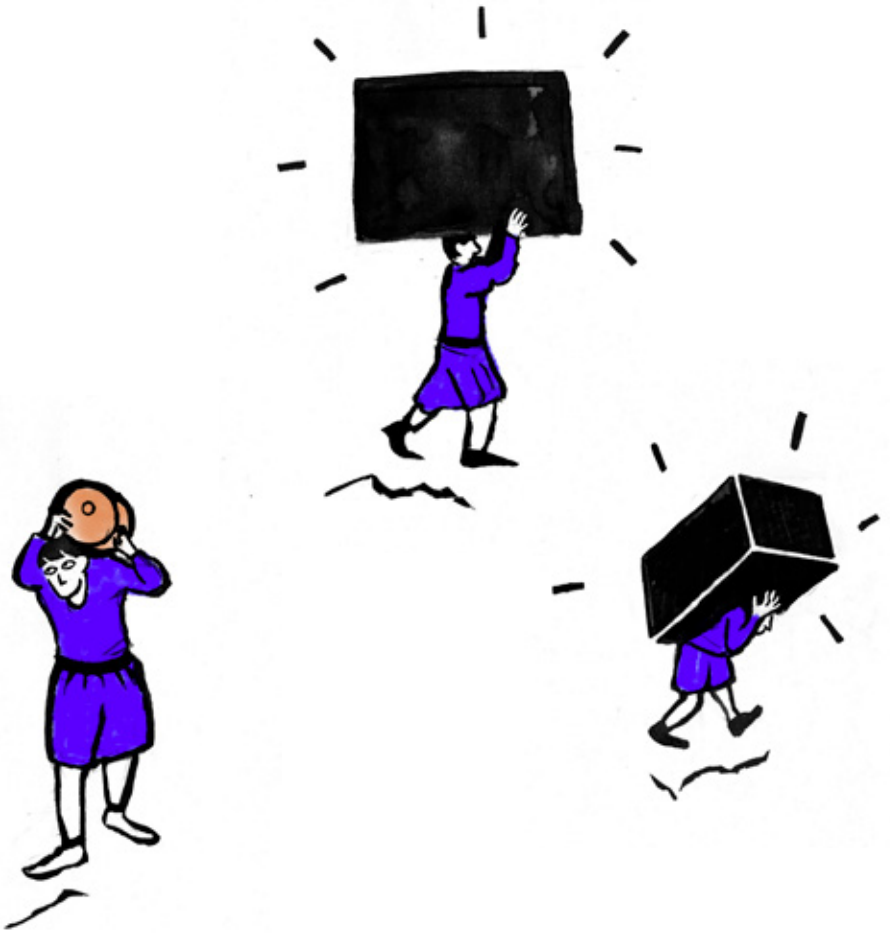
She had spent her childhood, constructing houses, villages, labyrinths, castles and cathedrals out of the driftwood, pebbles and stones on the beach. Building new creations out of the different things that were washed up by the tide, gave her endless pleasure.

The West Tower sat high up on the cliffs, exposed to the ferocious winds that blew in from the sea. The walls were made of sandstone, which was a tough local building material, but it could not endure the lashing rain and powerful winds that blew relentlessly over the western wall of the castle.

By the time the princess was sixteen, the windows had taken such a bashing from the weather that they had cracked and fallen apart. The carved chunks of sandstone holding the windows in place had been eroded so badly that they were disintegrating and crumbling down into the sea.



By now, Princess Lithosphere was no longer making play castles on the beach, she was designing real buildings. She had drawn up the plans and supervised the construction of the new castle bakehouse and storeroom. Everyone agreed that they were very fine, modern buildings.
It was now time to turn her blossoming architectural skills to re-building her own tower. She definitely did not want to let her precious tower collapse into the sea!



Firstly, she needed to replace the weather-worn outer stones and windows. Being on the coast, they had access to merchant ships that carried goods from all over the world. Her father secured a ship-load of white marble from Italy. In return the traders were given casks of whisky, as payment for the Italian stone.

The marble was beautiful, gleaming and sparkling in the sunlight. It was a harder rock than sandstone, so would stand up better against the wind and rain.

Princess Lithosphere sketched the plans for her new tower. Then a team of stonemasons followed her instructions, crafting every piece of marble with their hammers and chisels, until they fitted each stone neatly together like a gigantic jigsaw puzzle.

When the marble masonry was in place, glass windows were fitted all the way around the top of the tower, just like a lighthouse! This would flood the room with as much natural daylight as possible. Here she could work on architectural drawings, illuminated by the sun during the day and candles and moonlight by night.

On some of her windows she used thinly sliced and highly polished agate and jasper from local Ayrshire beaches and burns. The colours and patterns from these special rocks caught the sunlight, sending swirling patterns of green, blue and orange around her snug studio. The castle carpenter made her an elegant oak table and architect's drawing board. She even designed and built a room where plenty of fresh paper could be made – every architect needs good quality paper to draw their designs on.

Everyone thought her tower was the most beautiful in Scotland. Her friends visited often, to enjoy the wonderful light show as sunlight reflected off iridescent marble walls, and spirals of bright colour danced through the gemstone windows.

Atmosphere

> Atmosphere means all the gases over the Earth, and the gases trapped inside it.

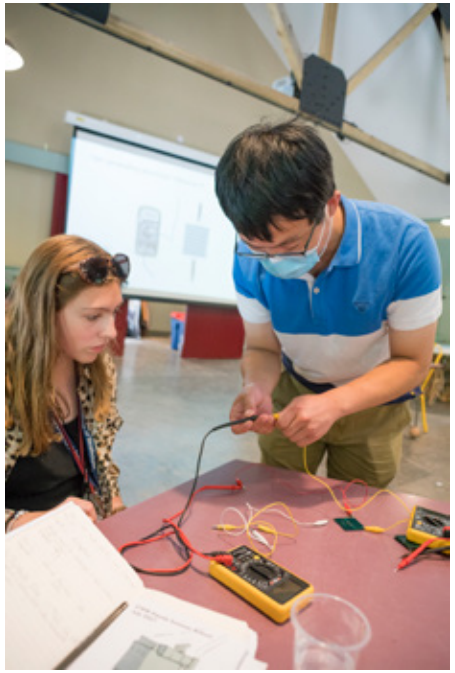
If we pollute the air, animals and plants will die, so this isn't sustainable. We need to find ways to cut down the pollution in the air. Rui and Agusti showed us how air currents can be used to make electricity, instead of burning fuel. Rockets, like the ones we made with Christie but much bigger, can be used to investigate the atmosphere high above the Earth.

Bottle Rockets

Dr. Christie Maddock
Aerospace Engineering

We made bottle rockets using water, vitamin C and Seltzer tablets. We tried mixing them in different amounts and placing them differently so they would fly well.
None of them went into space but a few of them jumped!

Making electricity without air pollution



We engaged with children and introduced how the offshore wind power is generated, transmitted, and supplied to households to light bulbs, which helped children understand why we need modern technology to control the wind power. We emphasized what we can do to tackle climate change to encourage children to engage in renewable technology. It was also very interesting to see many children show interests on the learning of Mandarin.

Dr. Rui Li

Dr. Rui Li & Dr. Agusti Egea Alvarez
Electronic and Electrical Engineering

King Atmosphere’s North Tower

Standing tall, with commanding views of the sea, on the northern corner of his stronghold, was the King’s Tower. On the top floor was a majestic room, where his friends gathered to discuss the latest news, politics, religion, but most importantly, they talked about astronomy. This was King Atmosphere’s greatest passion - watching the stars, planets and comets with his prized telescope.

The roof of his tower had been turned into an observatory, with clear glass windows and a domed glass roof. One of the roof windows opened for the brass telescope to be positioned through, giving uninterrupted views of the night sky.

The King wanted to learn all he could about the sky. He studied old almanacs – books filled with observations about the movements of the planets - and he corresponded with astronomers who shared his fascination with space and the Universe.

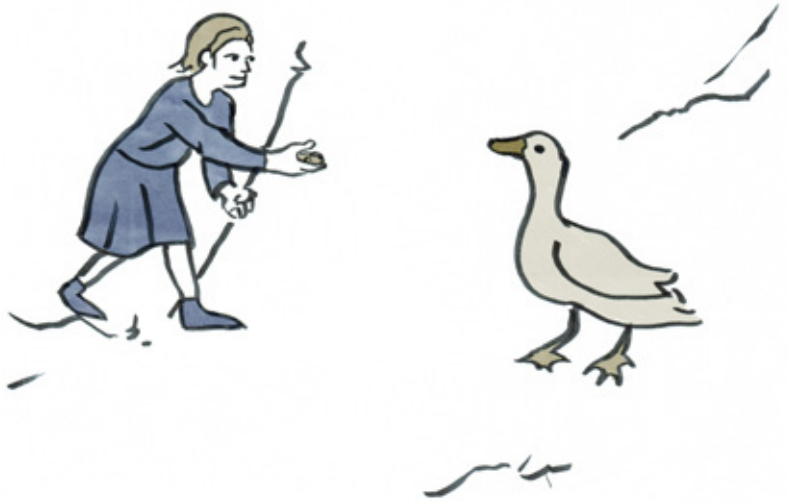
Maybe it was because the King was so busy watching the stars, or perhaps he was always occupied with the clever people who visited him, whatever the reason, the truth was that the lower half of his tower was a terrible mess. It was filled with every piece of castle junk that you could think of, from broken plates and pottery bowls to the bones of cattle butchered and eaten for dinner.

When the first two floors were full to the ceiling with unwanted rubbish, a servant would be sent to ask King Atmosphere what they should do with the waste. He would be so busy thinking about the latest meteor shower, or transit of Mars, that he would say the first thing that came into his head, like 'Oh, yes, rubbish … just chuck it out of the window!'

And this is why the hillside below the North Tower was completely covered in litter. Old broken beds, dirty straw and hay from the latrine, smashed glass, furniture, rusty weaponry, torn clothes, shoes, nuts and seafood shells. Covered in sharp bits of metal, glass, splintered wood and decaying bones, the land became too dangerous to walk on.

However, this didn't stop Thomas, a castle servant boy, who loved exploring the hillside. He'd bruised his shins and cut himself many times, but it was worth the injury, as sometimes he found useful things, like the end of a sword which he had made into a penknife.

One winter's morning, he found an injured duck. Thomas loved animals, and he felt sorry for the lame duck. He fed her oat bannocks, and over time her foot healed and she trusted Thomas enough to eat food from his hand.



In the spring, Thomas's duck built a nest and laid four eggs in it. Thomas did everything he could to protect her from foxes, dogs, hungry humans and bits of furniture being thrown out of the tower window.

Amongst the rubbish he found part of a rusty old shield and the remains of a barrel. He fixed the barrel and shield together and placed it over her nest. It created the perfect cover, protecting the duck and her precious eggs from falling objects.

King Atmosphere never did tackle the mess below his tower, instead leaving it for future generations of his family to clean up. They forgave him, because he'd passed on so much information about the stars. The knowledge of the planets filled people with awe and hope at what else might exist beyond our world. And Thomas's duck lived for many happy years, raising her ducklings safely under the protective shield of recycled rubbish.

Hydrosphere

> Hydrosphere means all the water on, and in, the Earth. This includes seas and rivers. It also includes water in air, which is in the form of clouds and rain.

Water turbines

We made water turbines, which can be used to create electricity with the power of water.
We tested a lot of different designs and saw which were most efficient.

Fermentation and biogas

Tosin showed us how useful bacteria and yeast can be. She showed us how they break down food (in our gut) or waste material (in our sewage) and make methane gas. The gas can be burnt, so the bugs are helping us to get energy from our waste, or making farts from our food!

Dr. Tosin Somorin
Process Engineering

Cola volcanoes

The cola experiment showed us how gas can be pushed out of liquid very quickly. This is what happens in volcanoes and also happens in the sea as it warms up. As the sea warms up, due to climate change, it gives out carbon dioxide, which causes even more warming. This is a problem for sustainability.

Prince Hydrosphere's East Tower

Prince Hydrosphere was an inventor. There was nothing he enjoyed more than tinkering with things and making new toys, gadgets and machines.
As he grew older, his parents gave him the East Tower of the castle. Here, he could design and build his inventions to his heart's content.
The only problem with the East Tower, was that this was where the castle toilet was.

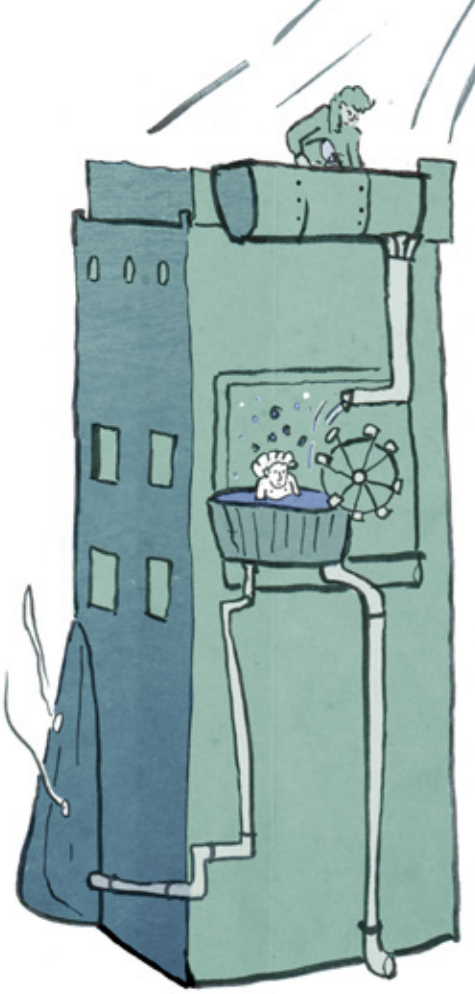
He knew how lucky his family were to have such a luxury – an indoor loo was almost unheard of in those times. Most people had to go outside and find a convenient bush to hide behind. Even when it was lashing with rain or blowing a snow blizzard, ordinary folk had to do their business outdoors!

It wasn't a flushing toilet, like we have nowadays - they hadn't been invented yet. This toilet was just a hole, carved into the solid stone walls. Everything deposited here went straight out of the hole and fell into a big heap on the ground below.

Prince Hydrosphere worked in the rooms above the toilet, but eventually the stench from the decomposing pooh outside, became so awful that it made him feel ill. So, he designed a small building to enclose the waste. It was very neat and air tight, with no gaps in the stonework – now, the dreadful stink was contained in the pooh-room.

One day, when his uncle was sitting on the toilet, he tapped out the burning embers from his clay pipe into the loo hole. All that uncle Kennedy remembers was the noise of the explosion, as he was catapulted upwards, hitting his head on the roof. When he came round, he was lying in a pile of rubble.

Prince Hydrosphere realised that the waste below had somehow made an explosive gas, which had blown up when the burning tobacco hit it. His uncle was back on his feet in a couple of weeks, but he always needed a big soft cushion to sit on, and he never rode a horse again!



The tower was re-built, and air-holes were made in the pooh-room for the gas to escape safely. Prince Hydrosphere carried right on building new gadgets; he made a big metal container, which sat on the top of his tower. Buckets of water from the sea were hoisted up to fill this tank. On hot sunny days, the water in the tank became warm. Then, he fitted a pipe for the water to flow down into his tower. This ran to a bathroom where it filled a large tub and shower. He built a wooden wheel for the water to turn a paddle of soft scrubbing brushes.

Everyone loved to soak in Prince Hydrosphere's warm bath, and get a great scrub from the rotating brushes in the shower.

The only problem was that because the water came from the sea, it was very salty and often contained sea creatures, so he made a mesh grill to filter out the bigger sea beasties, like crabs and lobsters. But the littlest one's - shrimp, tiny fish, water-worms, seaweed and baby crabs - always ended up in the bath!

Prince Hydrosphere still had work to do to make his inventions for the bathroom work perfectly.

Biosphere

> **Biosphere means all the living things on Earth.**

We went to Dumfries House and looked at different living things (moths, lichen plants) that are affected by pollution. If species are killed by human activity, the planet isn't sustainable any more.

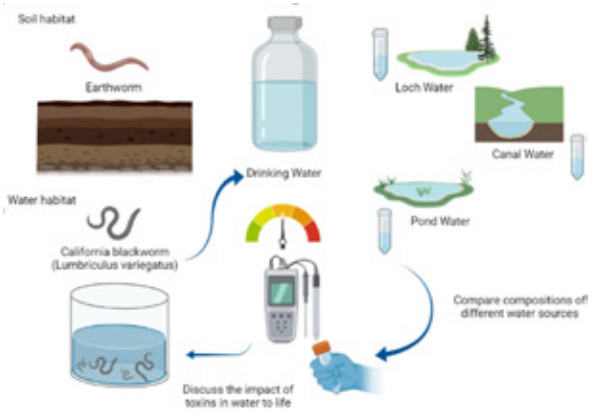
Bio-indicators: moths and lichen

Moths and lichen are bio-indicators, which means that they can show us the quality of the air around us.
We observed them, and determined that the air in Dumfries House was clean!

Worms

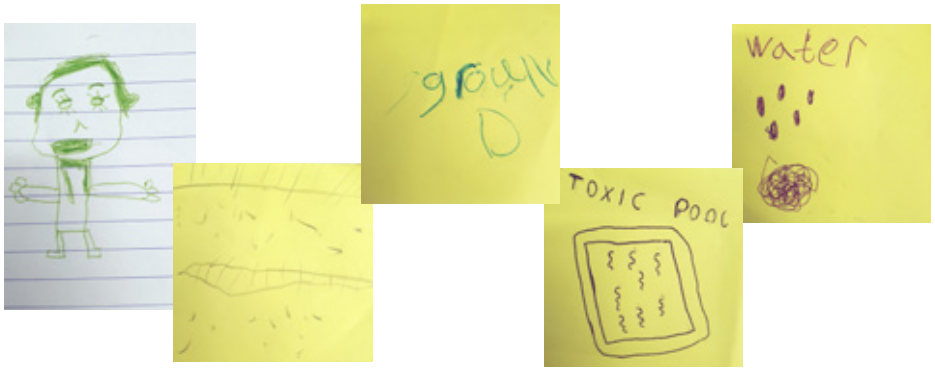
For the theme of sustainability, I decided to offer a range of activities to provide opportunity for the learners to explore how living things can adapt and respond to changes in their environment. For contextualisation, I brought earthworms (soil habitats) and California blackworms (water habitat) to enable the learners to visualise the different nutritional needs for each habitat to support different type of worm.

Dr Margaret Rose Cunningham
Pharmacy and Biomedical Sciences



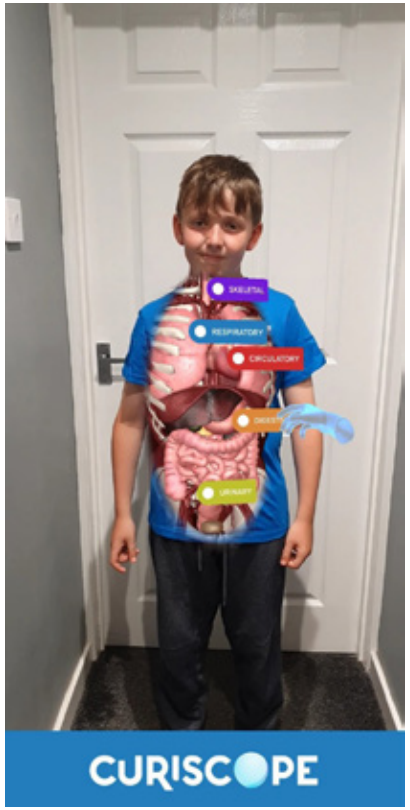
Many of the learners were able to recognise the nutritional needs of earthworms however they were curious about the blackworm due to their survival in water. I brought different samples of water from different parts of Scotland (e.g., water samples from Loch Lomond, local ponds and canals.) alongside a sample of water taken from a chemical treated hot tub.

We opted for a simple colour change test strip approach so that the learners could each have a turn to test the different water samples and compare the colour changes. After discussion of the test results and the learners hypothesised which environment would be optimal for the California blackworm. Learners had the opportunity to use a Pasteur pipette to transfer worms into a petri dish and monitor changes in worm behaviour and movement in response to the addition of the selected water sample (drinking water and samples from loch, canal, and pond). Through comparing the different test strips, the learners decided that the hot tub water would be too toxic for the worm to survive so we did not expose the worm to the water.



As a pharmacologist, although we look at the different ways drugs affect biological systems of the body to treat illness, we must also consider if there are any toxic effects of drugs that can cause harm to life. Translating these concepts to the environment and contamination of natural water supplies to sustaining life became its own reflective exercise for the learners to consider. Each participant had the opportunity to share their learning experience on paper through words or sketches on post-it notes or on notepads we provided each learner with to record their observations. Learners were given the chance to share their own reflections, which are shown below.

Digestion



Working in collaboration with STEM themes being explored by other scientists taking part in the STEM Equals project, I brought along a cross-reality (XR) Virtuali-Tee activity for learners to explore how their own body works to sustain itself. Volunteers wore custom Curiscope T-shirts, whilst the learners explored the different interactive features of the body using camera phone / tablet and a free downloadable application.
This was more of an inquiry-based learning approach that gave learners the opportunity to explore the physiological parts of the body they were most interested in knowing more about.

Painted stones

As a final activity for the last day of the summer school, I wanted to bring art into the STEM equation by facilitating a workshop for the learners to test their skills at rock painting with messages of sustainability. I designed some rocks with the message of 'Sustainability means looking after the Earth' and hid them on the grounds of Dolphin House for learners to find.
One of the highlights of the rock painting session was discussion on the theme each learner had chosen to paint on their own rock. Each managed to relate their painting to a character they encountered from cartoons, books, computer games and films. Conversations ranged from the sustainability of Harry Potter and his broom vs driving a car. Excellent examples of how learners placed context of sustainability to their everyday lives was insightful. Another learner used SpongeBob SquarePants as a point of conversation to discuss how life in the see could be impacted by pollution. There was no shortage of inspiration taken from everyday life and each example the learners chose to paint could be related in some way to sustainable living.

Queen Biosphere's South Tower

Queen Biosphere loved gardening. As the Lady of the castle, she could choose whichever tower she wanted, so she chose the South Tower. It was the most sheltered from wind and rain, and received more sunlight than any of the others – this suited her perfectly.

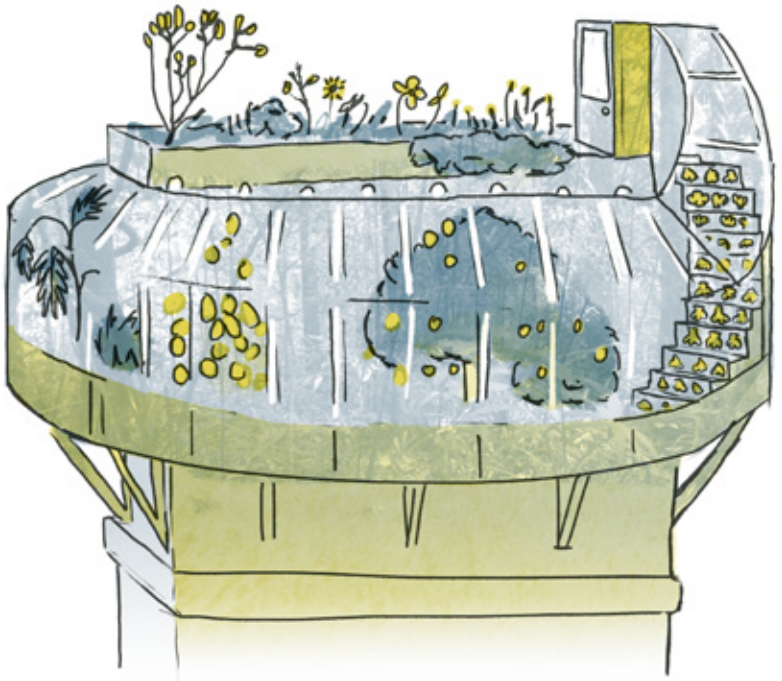
There were large walled-gardens at the castle, where gardeners grew the fruit and vegetables needed to feed the family and army of servants who lived there. Queen Biosphere liked to grow flowers, especially sunflowers. She had tried growing them in the castle courtyard, but either the castle crows ate them, or the pesky castle goats jumped over the wall and devoured everything!

The roof garden started with just a few old wooden barrels on the top of Queen Biosphere's tower. Here, she grew lavender and herbs, their scent wafting into her chamber, filling the rooms with relaxing perfume. Then she had the castle carpenter make wooden planters, which were positioned by the windows and filled with exotic plants and flowers, like jasmine, passion flower, magnolia and roses.

After a year or two, she noticed that some of the plants and flowers weren't looking as healthy as they had - leaves drooped and petals lacked their once vibrant colours. She asked the castle gardener for advice - he suggested 'Nice big earth worms and manure!' Buckets of goat droppings and horse manure were brought up the tower stairs and a servant carefully dug them into Queen Biosphere's pots and planters.

Then, a team of serving boys and girls were given the job of 'Worm Charming'. This involved tapping, thumping, drumming and dancing on the castle lawns – an ancient custom to charm the earth worms up out of the soil and onto the grass.

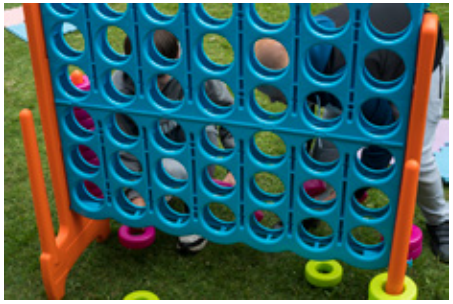
As each worm popped out of the ground, a child would carefully scoop it up and place it in a bucket. When the bucket was almost full of confused, wriggling worms, a servant took it to Queen Biosphere. Every Worm Charmer was paid a penny, and then each worm was placed in a pot or planter, where it could make it's new home. The hard-working worms and nutrient rich manure seemed to do the trick, the plants thrived, shooting out new stems, leaves and colourful flowers.



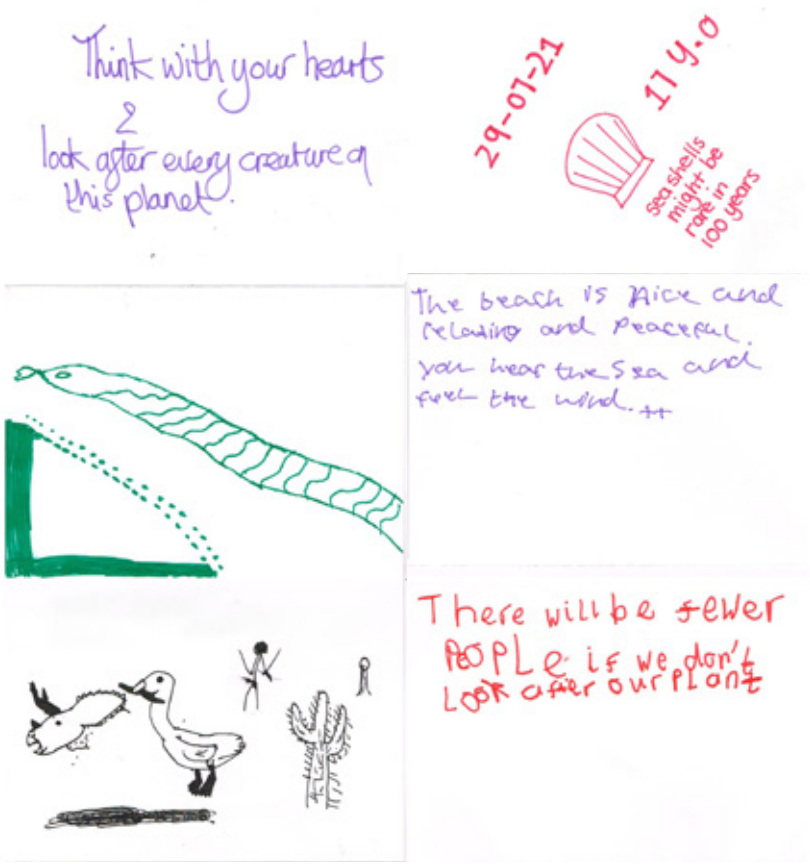
One day, Queen Biosphere consulted her daughter, the architect Princess Lithosphere, who designed a magnificent sandstone balcony, studded with smooth pebbles, for her mother's tower. It formed a circle around the top floor of the tower, with seashell decorated steps leading to the roof garden. Most of the balcony was covered by a pale green glass roof, which made a much warmer growing temperature inside for the plants. Her green-fingered mother used this as a green-house, where she could grow heat-loving Mediterranean plants like, grape vines, pineapple, orange and lemon trees.

Queen Biosphere's fruit cocktails were a big hit at summer parties, and no-one ever suspected that worms and manure were responsible for the lushness of the fruits!

Moments



Conclusion



The final day ended with the students voting for the most sustainable character in the stories, and leaving a drawing or note for future students in a time capsules.

Five characters from the stories were nominated for a sustainability award.
Students were undecided between whether Queen Biosphere should win because her tower produced flowers for the bees and other pollinating insects, as well as fruit to feed people at Culzean Castle, or whether the award should go to Thomas the servant because he recycled rubbish, and re-used it to make useful things like a pen-knife.

Thomas the servant was the winner, gaining more than twice as many votes as Queen Biosphere.
The students decided that recycling was the most sustainable activity, and it was something that they could do at home, so it was important to them and today's society.
Thomas was given extra votes because he was an ordinary boy, not born into a powerful, titled family, and because he cared for the injured duck. His love for wildlife and his smart use of rubbish to protect the duck's nest made Thomas the clear champion of sustainable practice.

Credits

Organisation

Dr Jane Essex

Scientists

Dr. Agusti Egea Alvarez
Dr Margaret Rose Cunningham
Noemi Giovelli
Dr. Aruna Ivaturi
Dr. Rui Li
Dr. Christie Maddock
Dr. Tosin Somorin
Dr Hong Yue

Preparatory workshops

Elio Caccavale
Dr. Michael Pierre Johnson

Learning staff

Pauline Hendry
Martyn Hendry
Will Essex
The staff at Dolphin House
The staff at Dumfries House

Stories, illustrations and books

Story credit and copyright:
Allison Galbraith

Illustrations, photography and layout:
Gaston Welisch