Epistemic Insight

ENGINEERING ED PROJECT

Q.

WHAT IS THE “BEST” SOLUTION?
CAN ROBOTS HAVE A SENSE OF CURIOSITY?
ARE THERE LIMITS TO SCIENCE?
WHERE DO ENGINEERS GO FOR ANSWERS?

WHAT’S THE POINT OF ALL THIS?

Engineers are working with education specialists to develop ways to help primary school students to experience the curiosity and wonder of thinking like an engineer. Workshops use big philosophical questions, storytelling, problem solving, scientific enquiry and historical enquiry to capture and hold students’ interest. Learning objectives relating to epistemic insight are included to develop and test students’ understanding. Teaching and learning epistemic insight is about empowering students of all ages with an understanding of how knowledge is constructed and tested within and across subject boundaries.

ROYAL ACADEMY OF ENGINEERING

Canterbury Christ Church University

ABOUT THE PROJECT

"Engineering is stories to solve"
"I want to be an engineer because they do experiments and tell stories about them"

WHO IS INVOLVED?

The Engineering Ed project is funded by the Royal Academy of Engineering and organised by the LASAR (Learning about Science and Religion) team at Faculty of Education, Canterbury Christ Church University. The project is working with engineers, engineering students, primary education students and primary schools in Kent and Thanet to deliver workshops that explore the opportunities, possibilities and big questions raised by engineering to Key Stage 2 pupils.

ENGINEERS

The project recruited eight engineers who work in industry and/or academia. We advertised the project as an opportunity for engineers to work with education specialists to design workshops for primary schools and to explore the relationships between Engineering and Big Questions. The engineers come from sectors as diverse as the Royal Engineers Corp., aerospace, software and electronics, materials and maritime engineering. Of these four have continued to work in a sustained manner with LASAR and the Faculty of Education beyond the initial events to further develop, deliver and research the impact of the workshop on pupils' understanding of engineering.

ENGINEERING STUDENTS

Workshops for primary schools were also designed and delivered by a full cohort of Level 3 Mechanical and Electrical Engineering Students at East Kent College (11 students). These students worked with LASAR and the Faculty of Education in teams to build their confidence in public engagement as engineers and design and deliver a workshop carousel at events on campus at CCCU. Their workshops continue to be included in events organised and delivered by the LASAR team.

BA PRIMARY EDUCATION STUDENTS

Eight BA Primary Education students worked with the engineers and engineering students during their training sessions to support the development of age appropriate and curriculum linked engineering workshops. In addition, they spent two days a week for a month in two participating primary schools focusing on engineering and science with the pupils, and then supported those students during their participation at two events on campus.

PRIMARY SCHOOLS

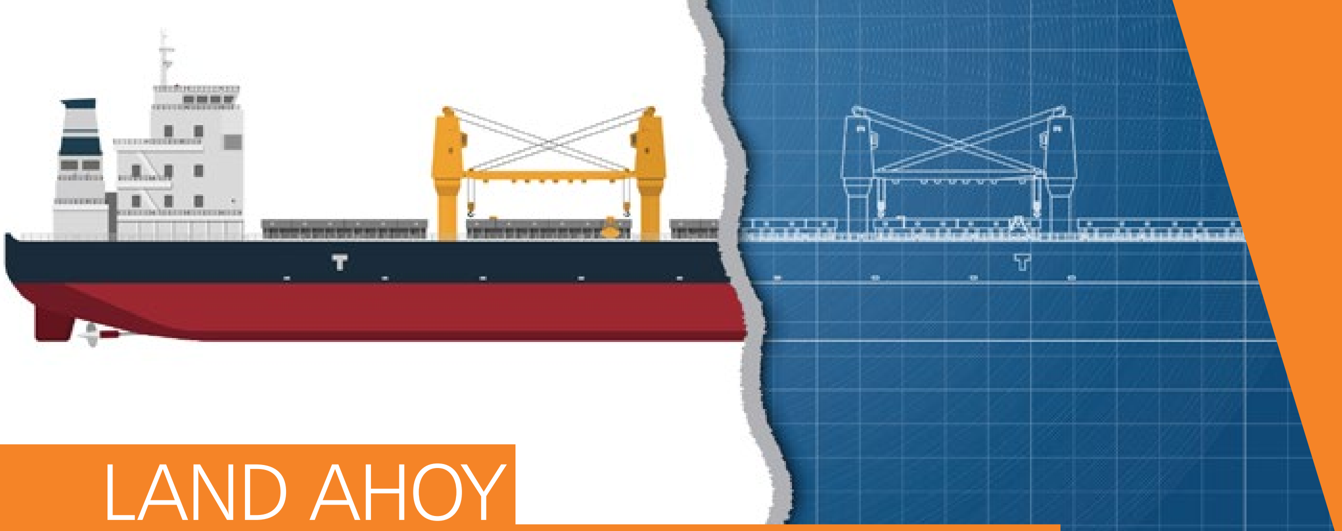
The contact with primary schools has varied from school to school and has ranged from one-off events to extended, sustained activities. For example at one primary school we worked with a full year group of year 5 pupils (approx. 60) across a series of sessions during January. These pupils attended two full day 'Engineering and Big Questions' events on campus and worked with BA Primary education students in school. Three schools have opted for Engineering and Big Questions Roadshow events in school. Five schools are participating in Engineering and Big Questions events on campus as part of the Epistemic Insight Initiative launch.

"I would like to be an engineer because they help people and build magnificent constructions"

FUTURE EVENTS

There are limited places available to have Roadshow events at your school in summer 2019
Stay tuned for our 'Engineering, Big Questions and Education' conference; autumn 2019

WORKSHOP 1



LAND AHOY – COPING IN THE HIGH SEAS!

Students will test their creativity as they take on the challenge of creating their own floating structures to carry a load. They will explore the concept that in science, weight isn’t the only factor to affect how well an object floats. We consider some historical stories to discover what they can tell us about what happens to the boats we build.

EPISTEMIC INSIGHT OUTCOMES

At school, we work in a multidisciplinary arena; engineering is a multidisciplinary way of thinking.

Think about this: Working scientifically we can discover some factors that affect how well a boat floats in the lab. Can historical knowledge add to our understanding of what affects whether a boat stays afloat?

KS3: In real life, people operate boats in diverse and individual ways. Can you explain how science and history each explain why a particular boat does or doesn’t float?

ENGINEER DESIGNER ANNA HAMPTON

Anna is a multi disciplinary engineer who works at managerial level supporting directors in emerging technology research and development. An agile and adaptable project and operations manager with ten years experience in the marine sector who specialises in safety systems and led the superyacht industry though a change of legislative compliance.

“The workshop's success is down to the heavy emphasis on practical exploration with everyday objects.”

HOW THIS SESSION HELPS PUPILS EXPLORE MULTIDISCIPLINARY LEARNING

Pupils are introduced to the HISTORY of boat making, exploring the development of coracles, canoes and ships and are invited to make hypotheses about the most important factors in building water transport.

Moving on pupils engage in SCIENTIFIC ENQUIRY making observations and recording their findings to establish which objects sink or float, they are challenged to investigate how the objects may be changed to alter their properties. They are introduced to scientific concepts such as density and ballast before being invited to build their own water transport to carry a load.

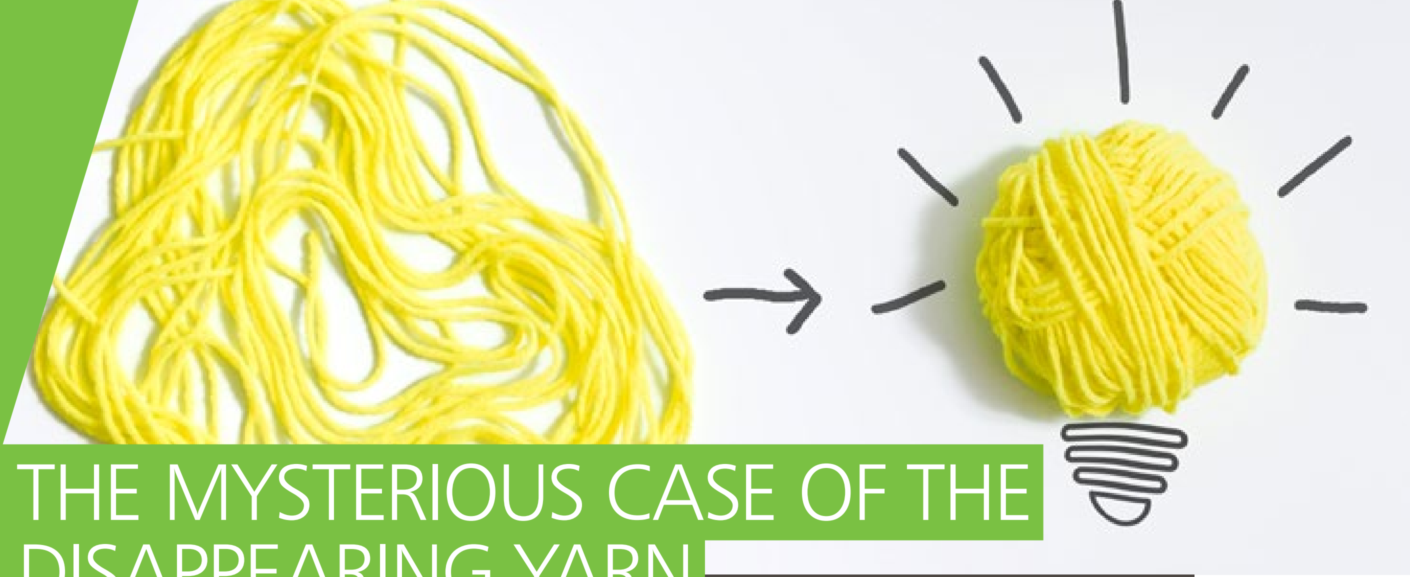
The final section of the workshop involves pupils in STORYTELLING and DESIGN as they build their own transport to carry a heavy load. Pupils examine how weight distribution and purpose affect the amount of load their transport can carry and are introduced to engineering concepts such as plimsoll lines and the HISTORY behind their design.

MOVING ON

Depending on the workshop length, and age of the pupils there may be opportunity to explore how these themes link to the production of RENEWABLE ENERGY (e.g. through floating solar panels) and the wider DESIGN and SAFETY requirements. Pupils may also be invited to examine how salinity affects buoyancy linking back to plimsoll lines and load weights. Alternatively, these themes can be linked in to timetabled science lessons or brought in to homework/ extension activities.

“I have been thinking that girls can do engineering too”
Pupil

WORKSHOP 2



THE MYSTERIOUS CASE OF THE DISAPPEARING YARN

Mr Faraday was upset. The balls of wool he regularly bought from the wool company were shrinking. The supplier, however, claimed that the yarn is unchanged and Mr Faraday's knitting is now looser. Students explore different methods to measure objects from the very small to the very knotted to try to address both claims. Now, do we think someone is cheating or is it an honest mistake?

EPISTEMIC INSIGHT OUTCOMES

Some questions are more amenable to science than others.

Think about this: In law, there's a big difference between an honest mistake and deliberate cheating. Measuring the wool helps a lot with addressing the question of whether the balls of wool are shorter.
Our other question is whether someone is deliberately cheating and this question is less amenable to the methods of science and maths. We can say that measuring the wool informs our thinking (it narrows the possibilities) but does not fully resolve the question.

ENGINEER DESIGNER VIVIAN TONG

Vivian is a Higher Research Scientist at the National Physical Laboratory. She uses electron microscopes to study materials such as those used in cutting tools and aeroplanes. The arrangement of atoms in a material can tell a story about its life - Vivian's work involves deciphering this, and also improving the microscopes so the stories we tell can be more detailed.

"[the workshops] use engineering concepts to probe the interface between "truths from the scientific method" and "truths from other sources", and I saw it as a niche I could fill"

HOW THIS SESSION HELPS PUPILS TO ENGAGE IN MULTIDISCIPLINARY LEARNING

Pupils are invited to examine how we MEASURE objects and to sort questions into those that are amenable to the methods of SCIENTIFIC ENQUIRY. Pupils are supported to design their own investigations using a range of equipment to establish which hypothesis is correct in the STORY of the Boyle Wool Co. They are introduced to the concept that some questions are more amenable to scientific enquiry than others.

Moving on pupils are introduced to SCALE and invited to think about how we can measure complex objects, designing their own investigations and creating the tools needed to carry out the measurements. Pupils are introduced to the idea that there are DIFFERENT METHODS for investigating different kinds of questions.

The final section of the workshop involves pupils examining the ways different disciplines may provide different EXPLANATIONS to the same observation, and that different disciplines have strengths in answering different kinds of question.

MOVING ON

Depending on the workshop length, and age of the pupils there may be opportunity to explore how these themes link to BIG QUESTIONS that cannot be fully resolved by science. Pupils can also examine how scientists make decisions about COMPETING EXPLANATIONS, and/or test hypotheses. Alternatively, these themes can be linked in to timetabled science lessons or brought in to homework/ extension activities.

"I had been thinking engineering was hard but it's actually fun because you […] get to help people and solve problems"
Pupil

WORKSHOP 3

THE NEVER-ENDING ICE CUBE

Engineers designing the solar orbiter needed a way to protect it from the heat of the sun. They applied scientific knowledge to choose materials and tested different designs in a lab. Students are given an ice cube and materials they can use to try to prevent it from melting. And then we see for real what happens when we put the ice cubes near the heat.

EPISTEMIC INSIGHT OUTCOMES

Scientific models help us to test and/or develop our knowledge, some situations are easier to predict and model than others.

Think about this: In real life, every situation is different. In this case, you cannot test your ideas in the place where you need them to work. How does scientific knowledge and working in a lab help us to design our answer to the problem? What are some of the reasons why our design might or might not succeed on the day?

ENGINEER DESIGNER
HELEN O'BRIEN

Helen is a Senior Instrument Manager at the Space Magnetometer Laboratory at Imperial College London. She is the technical manager of the Magnetometer, or magnetic field instrument, which will fly on the European Space Agency Solar Orbiter mission due to launch in 2020 to investigate the Sun up close.

"It was exciting to get involved with a project that provides hands on interactive workshops."

HOW THIS SESSION HELPS PUPILS EXPLORE MULTIDISCIPLINARY LEARNING

Pupils begin by exploring the challenges of sending objects in to SPACE, considering issues such as gravity, radiation and temperature. Pupils EXPERIMENT using a range of materials and equipment to decide how they will try to prevent their ice cube from melting once it goes near a heat source.

Moving on pupils develop their understanding of different methods of heat transfer and how they can be reduced or even stopped. Pupils DESIGN their own protective housing for their ice cube, designed to enable it to survive in 'extreme' conditions. They are introduced to the idea that there are different priorities in the design process and they test, observe and ASSESS the success of their design using a variety equipment.

The final section of the workshop introduces pupils to the REAL-WORLD example of the Solar Orbiter and develops their understanding that engineering is about problem solving – and that engineers often use a PROCESS of design, test, re-design.

MOVING ON

Depending on the workshop length, and age of the pupils there may be opportunity for students to REDESIGN and RE-TEST their solar orbiter designs. Pupils may also be able to test their original or new designs under VACUUM conditions. There are opportunities to link these discussions to questions examining the use of machines vs humans for SPACE EXPLORATION. Alternatively, these themes can be linked in to timetabled science lessons or brought in to homework/ extension activities.

"If I'm an engineer no matter what job I'm helping the world"
Pupil

WORKSHOP 4

MIND HOW YOU GO: CAN ROBOTS COPE WITH FAILING?

How do we get a robot to miss obstacles in its path as it travels from A to B? Students have a map and information about the robot. Can they write a programme (a set of instructions) that will take the robot, without a collision, from A to B? And How does the robot compare with a person in terms of navigating between points on a map?

EPISTEMIC INSIGHT OUTCOMES

There are limitations to our ability to predict reality (and then apply this to engineering problems). AI/Robotics provides a challenge to engineers because interaction with the world can't be easily predicted.

Think about this: Clearly we can't give a robot instructions about what to do in every situation. A simple robot follows instructions unquestioningly, without sensing what is ahead. What could you add to this robot to improve it and make it 'smarter'?

KS3/extension: Can you suggest a situation where people disagree about what action is best. What guidelines help us to make more difficult decisions?

HOW THIS SESSION HELPS PUPILS TO ENGAGE IN MULTIDISCIPLINARY LEARNING

Students are introduced to the formal definition of robot and learn about the ways that engineers design robots for a range of purposes. Pupils develop their understanding of how and why robots move. This includes learning about the roles of SENSORS and PROGRAMMES in shaping how robots interact with their environments.

Moving on pupils design a PROGRAMME to guide a robot from one point to another in a terrain. They also create their own STORY to explain the purpose of the mission. Having written the code students test their programme.

The final part of the workshop asks pupils to identify and discuss SIMILARITIES and DIFFERENCES between humans and robots in navigating unfamiliar environments. Pupils discuss the idea that engineers can learn from failure and give examples of how a robot might be redesigned to be more successful another time.

ENGINEER DESIGNER MIKE OH

Michael Oh has a Bachelors in Aerospace Engineering and Electronic Engineering from MIT. He started his company Tech Super Powers Ltd in his first year at university and continues to run it 26 years on. His expertise in understanding interdependent systems from aerospace engineering to raising twins. From hardware to software, Mike's motivation is to help others live and work with an appreciation of technology and its magic.

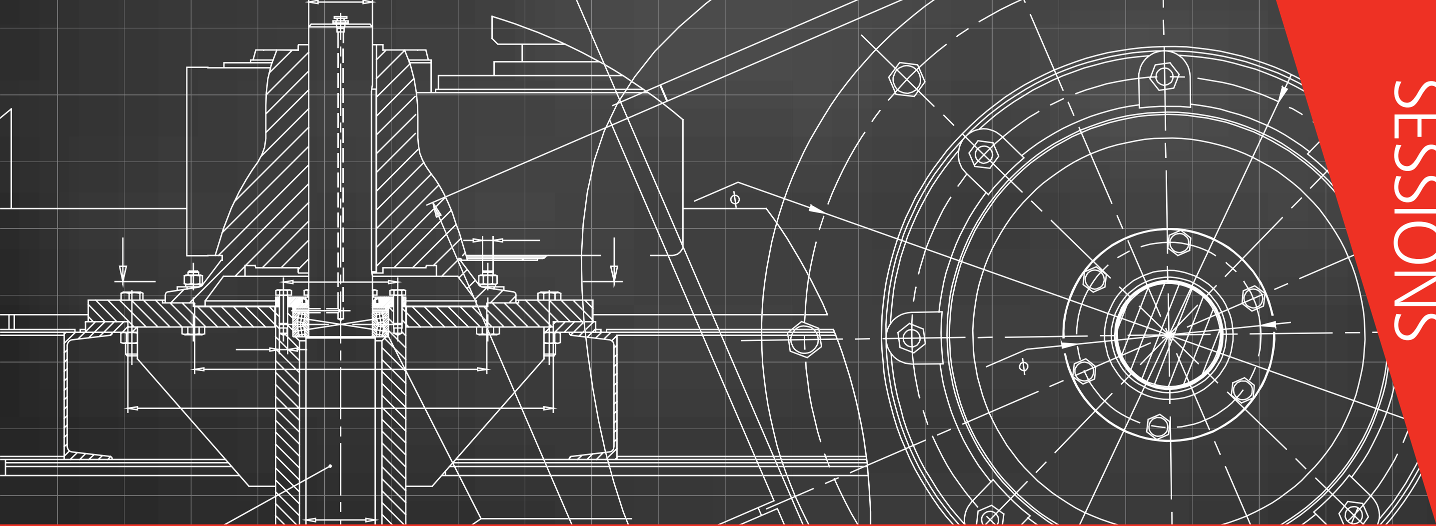
"[Pupils] are able to translate their enthusiasm for science fiction into an understanding of what makes a robot function on a faraway world."

MOVING ON

Depending on the workshop length, and age of the pupils there may be opportunity to explore how these themes link ideas of what it means to be ALIVE, develop more advanced CODING, or examine the ways in which different robots RESPOND to their environment and how they may be used to HELP PEOPLE. Alternatively, these themes can be linked in to timetabled science lessons or brought in to homework/ extension activities.

"[Engineers] can use robots to discover places and find solutions to their problems"
Pupil

CAROUSEL SESSIONS



WORKING WITH STUDENT ENGINEERS

Level 3 Engineering Students worked with specialists in education to design and deliver workshops for primary school pupils. Their mission was to design experiences for pupils that looked and felt very different to so-called 'recipe investigations'.

WHO DESIGNED IT?

The "Ready, Steady, Engineer" carousel was designed by level 3 engineering students from East Kent College. They worked in teams designing and delivering workshops that challenged their experience of recipe investigations in school science.

All the students are training for electrical or mechanical engineering fields and delivered the workshops to over 60 primary school pupils on campus. The LASAR team and Faculty of Education Staff are developing the workshops building on the students' ideas.

HOW THIS SESSION HELPS PUPILS ENGAGE MULTIDISCIPLINARY LEARNING

These sessions were originally designed as a carousel to challenge pupils' misperceptions that there is one "correct" answer. All the workshops focus on providing pupils with time to tinker and DESIGN and/or ADAPT their solutions to a given problem.

Pupils are encouraged to be CREATIVE in their problem solving and encouraged to revisit and adapt their designs during the process. As well as promoting the concept of multiple correct solutions to the same problem, pupils also explore how we use SCIENTIFIC LANGUAGE and that "best" solution is dependent upon the design criteria, context and materials/time available.

THE TIN SNAIL

Pupils are challenged to think about the properties of recyclable materials and explore problem solving, design and recycling in engineering through a STORYTELLING FRAMEWORK. They develop an understanding that design criteria are often influenced by issues or concerns that aren't associated with working scientifically.

BRIDGE TO A NEW WORLD

Pupils explore bridge design through the dual lenses of AESTHETICS and MATERIALS. They are encouraged to be creative in combining materials for structural strength and design whilst also working to bring their priorities in on time and to cost.

LEANING TOWERS AND ALIEN HELIPORTS

Pupils have to think CREATIVELY in designing a structure that can be adapted for an (as yet) unknown use. They are encouraged to explore the properties of different materials before working as team to adapt their design in the light of new criteria.

"[Engineering] takes planning and you have to be creative"
Pupil

EPISTEMIC INSIGHT OUTCOMES

The "best" design for an object or experiment depends on the kinds of questions we ask and the disciplines that inform the answers.

Epistemic Insight

Developing epistemic insight is about empowering students to understand how knowledge is formed and become confident scholars able to tackle some of the BIG questions across a range of topics. Ensuring students are equipped to be able to explore and challenge the "solutions" and encouraged to keep asking questions!

Principle Investigator: **Berry Billingsley**
Lead Research Fellow: **Finley Lawson**
This booklet offers an interim introduction to the Engineering Ed project.
For more information email: **lasar@canterbury.ac.uk**

Canterbury Christ Church University