INSPIRING MINDS

Through Informal Science Learning:

Interim Evaluation Report

Informing research to increase science learning in schools

National Collaborative Outreach Programme

KMPF
KENT & MEDWAY PROGRESSION FEDERATION

Canterbury Christ Church University

INSPIRING MINDS

The Inspiring Minds sessions empower students with new ways to think about themselves, their school subjects and what they can do next. In order to do that they need commit to coming to each session with an open mind and willingness to ask big questions about their world.

The activities build their ability to think across their subjects and beyond, to ask good questions and to make good use of what is already known to achieve their CREST award.

This is their chance to show the world what they are made of, what has inspired them and to inspire us with their solutions!

Epistemic Insight

Canterbury Christ Church University

Inspiring Minds through Informal Science Learning: Interim evaluation report.

Informing research to increase science learning in schools

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Forward

The Inspiring Minds programme is designed to develop confident scholars who can produce and present science and engineering projects while building their understanding of how to address questions at the frontiers of current knowledge.

In my role as academic consultant, I've had the pleasure of seeing the initial ideas become session plans for a series of Saturday morning workshops for young people and of attending the final showcase.

It's clear from the recruitment materials that Inspiring Minds seeks to attract upper secondary school students who are curious about the world around them and engaged by big philosophical questions about the nature of reality and human personhood. As a project designed to widen university participation, it is an audacious and aspirational strategy and yet sits very well with the goal to find young people who would really benefit from what university can offer and who are potentially going to miss out for all the wrong reasons.

Students taking part in Inspiring Minds begin with a workshop with academics designed to raise their epistemic insight (their understanding of how knowledge and scholarship work) and then construct their own enquiries. In the spaces of a few Saturdays students engage with intellectual puzzles about the nature of reality and human personhood in the lights of science, artificial technology, religion and mathematics. They investigate whether a robot can think for itself, the secrets of optical illusions and the power and limitations of our senses to reveal the true nature of reality, whether mathematics is already present in the universe or whether people invented it and how they represent themselves online and the concept of a self-portrait in the modern digital age. This research informs their engineering projects, where they are developing their capacities for problem-solving in the real world and experiencing for themselves the multidisciplinary nature of engineering.

At the showcase, students' enthusiasm and confidence when they presented their projects was astonishing. The showcase abundantly met the aims of demonstrating students' academic potential to friends, family and university staff at the exhibition, while helping students to feel empowered and valued as future members of a university community. At every display in the exhibition, young people came forward to explain their projects and what their enquiries had revealed. The survey and interview data discussed in this report only partly capture what was evident on the day. For next time, richer methods of data gathering and analysis would be useful. As a guest touring the projects, I was struck by how deeply the students had connected with the questions they were exploring. I also noted that for their engineering project, students had in almost all cases, designed technological ways to address problems and hardships which they perceived to exist in the world.

One group showcased a series of optical illusions and explained what optical illusions can reveal about the ways that we see and interpret our observations of the world. They connected this understanding with creating ways to help people who are disadvantaged by differences in how their visual system work. They talked about loss of colour vision at dusk for everyone and constructed a project which explained how medical engineering and other technologies might one day help people to overcome colour blindness.

A second group took the question –can a robot think for itself. They were very interested in 'choice' – and whether algorithms that simulate choice are really giving the robot a choice or telling the robot which choices to make. For their engineering project they wrote and demonstrated algorithms at work using a range of computer based applications and commercially available robots.

Another group highlighted the beauty of nature and drew on their growing understanding of the issues around plastics in oceans and air pollution to explain the importance of protecting the planet. Students explained that in nature we find mathematical patterns that we can't yet explain and so they seem mysterious to us. They explained that the course had given them new ways to talk about the interconnectedness of nature and also the importance of epistemic humility – of recognising that there are many aspects to how nature works that we don't yet understand.

It has been a wonderful experience to work with the KAMCOP (Kent and Medway Collaborative Outreach Programme) Team on this project and very good news indeed that it will continue, while also developing new approaches that will enable a larger number of students to participate.

Dr Berry Billingsley
Professor of Science Education
Principal Investigator of the Epistemic Insight Initiative

Executive Summary

The project:

The UK Government aims to widen the participation of students from under-represented groups in Higher Education by doubling the proportion of certain groups in the sector by 2020 through the National Collaborative Outreach Programme (NCOP). As part of NCOP in Kent and Medway, Canterbury Christ Church University developed two outreach activities designed around the latest thinking in STEM in order to raise aspirations around HE and STEM education and careers. In partnerships with the LASAR Centre at Canterbury Christ Church University, the two projects (Inspiring Minds: ISL and Summer School) were arranged around and Informal Science Learning Curriculum.

Evaluation:

A mixed methods, sequential design consisting of repeated measures surveys and semi-structured interviews was used to assess the extent to which the ISL curriculum could influence student's intention to pursue STEM at HE and perceptions of HE more generally. The impact of intensity on the outcome of these activities and also how the curriculum could change student's perceptions of STEM was also considered.

The Programme successfully fulfilled its 6 primary objectives:

Objectives	Measures	Achieved
Participation of KaMCOP ward learners and female students	90% of participants are from KaMCOP wards Proportionally higher participation of females	✓
Participants to report an increase in their academic motivation and confidence	Increase in level of agreement with statements relating to educational aspirations and motivation measured using repeated survey statements Students are more likely to say they will apply to HE in the future, measured using repeated survey statements.	✓
Participants to report that they feel more positive about pursuing STEM related education and careers.	Students are more likely to say they plan to participate in STEM in the future, measured using repeated survey statements. Thematic qualitative evidence describing perceived benefits of participating in STEM outreach and how this might link with future educational and career options	✓
Participants to report that they can see the wider relevance of STEM	Students are more likely to say they recognise wider social benefits of STEM, measured using repeated survey statements. Thematic qualitative evidence describing perceived benefits of STEM in society and how this might link with their future educational and career aspirations	✓
Participants to report benefits to their perceived sense of self	Students are more likely to agree to statements relating to self-concept in STEM and more general statements relating to self-efficacy, measured using repeated survey statements. Thematic qualitative evidence describing perceived benefits of STEM outreach for building a positive sense of self.	✓
Participants to achieve a Bronze CREST award.	Over 80% of participants to pass Bronze Crest	✓

Results:

- 64% agreed or strongly agreed that the activities left them feeling motivated to study STEM post-16
- 68% indicated that taking part encouraged them to find out more about HE.
- Statistically significant improvement in measures related to: future intention to participate in STEM (whether in HE or at work, $p < .007$), perceptions of HE ($p < .012$) and intention to apply to university ($p < .027$).

Qualitative Interviews also gave an indication of changes in motivation around Higher Education:

"I didn't really think about University before but it's really shed a new light on it and I definitely want to go now"

"it's definitely allowed me to look at new job opportunities"

"The Bloodhound project helped me strongly with my physics"

"I've always wanted to go to university and experience lectures and stuff like that because it was just something for me to think about because no-one in my family has been to university before".

- 75% of learners felt the projects helped them understand the links between science and other subjects
- 80% reported that the projects made them more supportive of the benefits of science.
- 57% of students felt more confident in science lessons
- 60% felt more confident contributing in lesson as a result of the programme.
- Over 5 measures of self-efficacy there were significant changes to indicate improvement of how people felt about their abilities.

These results were consistent regardless of intensity of activity.

- 84% achieved their Bronze CREST award. Interviews also suggested that students felt the project had improved their school work.
- Students enjoyed opportunity for independent learning, seeing it as an experience of freedom and a chance to form their own opinions.

Introduction

The UK Government aims to widen the participation of students from under-represented groups in Higher Education (HE). This aspiration includes the goals of doubling the proportion of young people from disadvantaged backgrounds in higher education by 2020 and increasing the number of students from ethnic minority groups.

As part of the National Collaborative Outreach Programme (NCOP) in the Kent and Medway region, Canterbury Christ Church University has developed outreach activities conceived around the latest thinking in Science, Technology, Engineering & Maths (STEM). Two projects, 'Inspiring Minds' and Summer School, aim to enable young people to become confident scholars who can engage with difficult philosophical questions raised by current technological advances as well as to help them develop strategies for coping with the stresses and anxieties of educational environments.

A core aim of these projects is to encourage progression in to HE and moreover, following the publication of Science and the Youth Sector report (Wellcome, 2017), the 'Inspiring Minds' and 'ISL Summer School' projects aim to investigate the impact that Informal Science Learning (ISL) can have on young people's perceptions, attitudes and aspirations around STEM.

ISL and informal STEM education takes place outside the classroom environment and aims to inspire students through hands-on, experience-based activities that can enrich and add value to their school experiences (POS&T, 2011). ISL may be beneficial for young people from disadvantaged backgrounds, who are more likely to find science subjects challenging and unengaging at school (Wellcome, 2012). The STEM focus of the Canterbury Christ Church University projects presented in the following report also brings additional dimensions to the widening participation challenge, where there is also a keen interest in encouraging students from diverse socio-economic backgrounds, and females particularly, to pursue STEM careers (Grove, 2013; ASPIRES, 2013).

It is thought that intensive and engaging STEM outreach can encourage students to consider STEM careers. Current research however shows mixed findings on the impact of STEM enhancement activities on improving the likelihood of those prior mentioned, under-represented groups continuing to study STEM subjects (Banerjee, 2017). However, evidence suggests that conveying the wider relevance of science (a core aim of these projects developed through collaboration with the Learning About Science and Religion (LASAR) team at Canterbury Christ Church University and their work on epistemic insight) can help foster students' interest in and perceived utility of science, which may then encourage aspirations towards science careers (Sheldrake, 2017).

There is also evidence that students are more motivated and can find greater meaning in science education when the learning is contextualised within real world problems. With contextualised learning providing the additional benefit of helping students to deepen their understanding of the nature of science and scientific practices (Allchin, 2013). This was an additional reason for the partnership between the NCOP team and LASAR Centre in the Faculty of Education at Canterbury Christ Church University who examine the impact of curriculum compartmentalisation on student's perceptions of science in order to assess the impact of ISL on understanding and perceptions of science.

As part of the wider context around ISL consideration can also be given to 'science capital'. The five evidence-based messages from Archer, DeWitt & King, 2018 suggest that young people's encounters with science are based on an approach to science capital education and epistemic insight (Nomikou, Archer & King, 2017) and focus on sustained approaches. They also state that the focus should be on connectivity to create pathways, progression and partnerships.

The ISL activities created by Canterbury Christ Church University and LASAR were developed in order to give those students with little to no science capital the interest necessary to build these skills through the creation of connections with individuals working in that industry through the activities run with them. Individuals from a widening participation background and in particular those from KaMCOP wards have an unexplained gap between achievement and progression. This potentially may be through a lack of connections creating a lack of social capital and potentially science capital also. The projects delivered by Canterbury Christ Church

University endeavoured to help students form those connections.

It is also thought that STEM outreach can have a positive impact on the attainment of more disadvantaged students (categorised by FSM eligibility). Research has shown that achieving a Silver CREST award correlated with a small increase in students' best science GCSE compared to a matched control group (Pro Bono Economics Research, 2016). Some of the participants in this report, those who took part in Inspiring Minds, completed their Bronze Crest Awards.

Using data from repeated measures surveys and interviews, this report summarises the interim evaluation of these two projects that were run between January and December 2018 - Inspiring Minds ran for two cohorts, the first starting in January and ending in June and the second starting in September and ending in December 2018. The Summer School ran intensively in July 2018 with two groups, mixed and boys. The repeated measures approach forms part of the broader evaluation strategy to track the participants' outcomes, including post-16 participation in STEM for the participants compared with a non-participant matched cohort, and ultimately, progression into HE.

This longitudinal approach will help to build evidence to substantiate whether or not ISL approaches can change the aspirations of young people and whether this can be linked to their future educational and career choices. This need for longitudinal work has been identified in the Wellcome Trust's (2017) Science and the Youth Sector report, which broadly defines the knowledge gap for this evaluation to sit within. This report will be updated as further data becomes available and as more cohorts complete the programme.

Educational Collaboration

In aiming to increase the diversity and participation in HE in general and STEM in particular these projects posed two key challenges that needed to be addressed. The first is to present informal STEM learning in a way that is meaningful and engaging for the students; the second, and arguably more pressing, is that before students can consider participating in STEM in HE they must first be able to see themselves as confident scholars with the critical thinking skills and epistemic insight to engage with and contribute to the discussion. Without first developing their self-concept as scholars changing their perception of STEM in isolation will not change their perception of (STEM at) HE as an attainable goal.

The need to understand and identify ways to overcome these challenges in a meaningful and substantive manner led to the collaboration with the LASAR Centre in the Faculty of Education at Canterbury Christ Church University. Research undertaken by the LASAR team (Billingsley, 2017) examines the impact of curriculum compartmentalisation on students' perceptions of science and in turn how pedagogy influences their expectations about the relevance of science for them. Through the work on these projects and through separate externally funded work LASAR is at the forefront of educational research into the development of a curriculum framework (Billingsley et al., 2019) that challenges students' misperceptions of the relationship between science and other subjects.

By underpinning the development of the project activities with the educational research the aim was to design an ISL strategy that addressed students' identified misperceptions and barriers to engagement with STEM. Therefore, beyond the widening participation agenda the additional research aim of the project was to test whether sustained engagement with big philosophical questions around science and technology would impact students' understanding of/engagement with STEM. The deliberate approach o highlighting STEM beyond the "concepts" delivery seen in schools has been argued to offer one of the most transformative learning shifts with using problem or case-based learning (Allchin, 2013).

ISL Rationale

The Inspiring Minds' curriculum was designed to not only offer and evaluate sustained outreach engagement to improve HE uptake, but also to implement and trial ISL that develops students' understanding of the power and limitations of scientific knowledge as part of a wider research project. The power and limitations of science (sometimes called 'epistemic humility') is both a curriculum objective in science KS4 and a central aspect to the development of epistemic insight.

Further research by Billingsley et al. has highlighted the current compartmentalisation of the curriculum alongside other pressures and barriers within the UK educational system systematically dampens student's interest in Big Questions. When this is understood in connection with research on the importance of science capital (Wellcome, 2017) students from low participation backgrounds are far less likely to have opportunity to develop their understanding of the strengths and limitations of science in real-world contexts and multidisciplinary arenas. Furthermore, those low-participation students are less likely to develop their epistemic insight and associated habits of mind that are required for innovative approaches to teaching STEM within HE, such as the CDIO (Conceive, Design, Implement, Operate) approach to engineering education.

It has been argued (Craven, 2002; Schwartz et al. 2004; Seeker 2005) that teaching about the nature of science needs to be both explicit, and whilst this is part of the science national curriculum, it is currently not assessed and therefore remains under resourced within school science teaching. The underpinning concept in developing an ISL curriculum that examines big philosophical questions that bridge science and other disciplines is not to simply provide students with additional scientific *content* but to also *engage* them in the discussion through the support and scaffolding of a research-informed ISL curriculum. The divide between scholar-led and student-led activities enables students' engagement with the nature of science to explicit *and* reflective so that there is opportunity to discussion the nature, power and limitations of the sciences.

In developing outreach activities that also fulfil an ISL agenda a further question is raised as to whether the activities should be focusing on knowledge application or knowledge generation. Knowledge application refers to the students being able to use knowledge they already have, whereas knowledge generation refers to students generating new knowledge (with the newness being relative to the student). In an informal setting with students from multiple schools and ability range in each session the curriculum cannot be based on assumed prior scientific knowledge this can lead to a focus on knowledge generation over application. However, with a key aim of the activities being to foster students' confidence in their abilities as scholars this has the potential risk of leaving students feeling just as disenfranchised and unable to engage as they do in school.

The epistemic insight curriculum approach is innovative through the focus on the use of multidisciplinary big questions, enabling students to engage with both tasks. Students can access the STEM activities (including the CREST award) through application of their existing knowledge in science and (as importantly) other disciplines. The nature of the curriculum provides multiple access points to STEM engagement through a multidisciplinary and "Big Questions" framework. This aims to ensure that students aren't faced with a starting point of feeling unable to undertake STEM research because they have already disengaged from/had a poor experience with STEM at school.

Therefore, in providing a vehicle to overcome misperceptions and barriers to STEM engagement students are presented with an opportunity to both apply their existing knowledge and engage with knowledge generation. For some students the generation is through the development of their STEM content knowledge whereas for others it is through developing their epistemic awareness of the links between and powers/limitations of different disciplines.

In addition, the curriculum for Inspiring Minds (and the Summer Schools) were designed to offer an alternative to the close-ended epistemic processes modelled within formal science learning. Close-ended processes require students to find a single "right" answer to the question/project, this model can lead to students feeling under pressure with a fear of "getting it wrong" that can negatively impact their engagement (Allchin, 2013). The use of Big Questions, and student-led investigation enables students to contribute to the STEM debate and facilitates their entry at different levels by enabling them to develop their own smaller close-ended process/question (through a narrow

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focus CREST project for example) or to continue to engage at an open-process level where the output draws together approaches or responses from a range of disciplines. The impact of this approach to informal STEM activities is drawn out in the interview responses form Cohort 1 and the curriculum has undergone formative evaluation and development at the end of each cohort in response to the student feedback.

Overview of activities

'Inspiring Minds' is a six session programme (Table 1), held on a Saturday at the university campus that is targeted towards young people studying in Year 10. Cohort 1 ran over six months with monthly sessions (January to June 2018) and Cohort 2 ran over three months with fortnightly sessions (September 2018 to January 2019). The programme focuses on building confidence and awareness of STEM in a multidisciplinary context with each session having two parts (1) a guest speaker on STEM in a multi-disciplinary context and (2) a student run session working toward their Bronze CREST award[1] in groups led by trained student ambassadors. Students were incentivised with £30 High-Street vouchers for attending each session.

Table 1
Summary of Inspiring Minds sessions

Session	Session aims
Who am I online?	To experiment with social media profiles. To discuss how the ever-present image of the online self affects and reflects who we are.
Does Siri "just" listen?	To challenge the language used to discuss technology. This session will also work to challenge the assumption that science can or will know everything.
What's the universe really made of?	To help students see maths as a language, and understand how everything we currently know of in the universe living and non-living reflects this language.
Is seeing believing?	To explore how senses, thinking and memory can be manipulated. To examine fundamental parts of what makes us human and where we place our trust.
Show Case preparation event	To plan for the showcase.
Showcase exhibition	To present CREST project and wider Inspiring Minds work to an audience of academics, parents/carers and peers

The ISL Summer Schools focused on high intensity activity, on a residential basis with fully trained ambassadors and engagement in academic and social activities. Two five day residential summer schools (mixed and boys) in July 2018 were based on the Canterbury Christ Church University campus and had up to six academic sessions during the course of the students' stay. The Blood Hound Education Team ran the academic sessions for both Summer Schools focussing on effective car design for land speed records. Students were not incentivised for taking part in the Summer School.

Overview of ISL Summer School 2018 sessions

Air Car Workshop – Students designed and build a car from KNEX that were powered by air pumps, cars were tested on a track and then raced under timed conditions. Students learnt about forces, aerodynamics and introduced them to the mathematics around calculating speed.

Model Rocket Car Workshop – Building on the knowledge gained in day 2 students designed and build rocket cars from foam blocks, these cars then had a rocket fitted and were tested over a 100m track for speed and thrust.

Clay space workshop and Escape room. Afternoon trip to Dreamland in Margate

Morning sports events and afternoon awards presentation and departure

1

Canterbury Christ Church will be hosting two more ISL Summer Schools in 2019. The Summer Schools will have a particular focus on engineering in line with the STEM agenda nationally and the Govt. Industrial Strategy. The Summer School will demonstrate the pioneering CDIO international engineering education model, developed by the Massachusetts Institute of Technology (MIT) in collaboration with business.

The first summer school will be for a mixed cohort of Year 10 students and the second exclusively for Year 12 girls. Summer School 2019 will focus on Engineering and will cover these three key areas:

Biomedical Engineering:

Students will learn about key advancements in robotic prosthetics as a gateway to the multidisciplinary STEM field that combines biology and engineering, applying engineering principles and materials to medicine and healthcare. The combination of engineering principles with biological knowledge to address medical needs has contributed to the development of revolutionary and life-saving concepts such as: Artificial organs, surgical robots, advanced prosthetics, new pharmaceutical drugs and Kidney dialysis. Through learning about the use and advancement of prosthetics and robotics in health care, students will also learn of the increasing demand for Biomedical Engineers linked to society's general shift towards everyday utilisation of machinery and technology in all aspects of life.

Chemical Engineering:

By creating a ubiquitous item such as soap, considering dermatological effects, scent etc Summer School students will be introduced to the breadth of chemical engineering as a branch of engineering that uses principles of chemistry, physics, mathematics, and economics to efficiently use, produce, transform, and transport chemicals, materials, and energy often into everyday products. Canterbury Christ Church University will demonstrate how Chemical engineers focus on processes and products - they develop and design processes to create products.

Product Design:

Product Design engineering develops a device, or system as an item for sale through the manufacturing process. As part of the creation of a chemically engineered product Summer School, students will have to 'bring the product to market'. As Product Design engineering usually entails activities dealing with issues of cost, production, quality, performance, reliability and user features. Students will have to design packaging, create focus group campaigns, evidence their testing methodology and form a marketing campaign. This will be delivered in collaboration with a leading firm and the Canterbury Christ Church University Business School, further emulating the MIT CDIO model.

Evaluation Methodology

This interim evaluation report (which forms part of a larger, ongoing research project) was designed as a mixed methods research project using a sequential research design to guide the project in terms of framework and analysis. The design incorporates two types of data, quantitative and qualitative, collected for separate purposes. Part of the KaMCOP goal is to evaluate activities with target students. In this interim report this was done by collecting quantitative data through repeated measures questionnaires collected at the beginning of activities (baseline measures) and at the end of activities (post-activity measures).

Following the collaboration with LASAR on the creation of the ISL curriculum used in the activities, it was decided to collect qualitative data through semi-structured interviews with students who had taken part in activities, to add some level of depth and meaningfulness to this report and the wider research project around the impact of ISL on attitudes around STEM and to further the Faculty of Education's research on how to improve science learning in schools. .

KaMCOP evaluates activities within the context of the NCOP programme aim to *"demonstrate which interventions (in which contexts, and with which learners) have been instrumental in delivering progress, and which could have the most impact in the longer term"* (HEFCE, 2016).

The KaMCOP evaluation strategy is aligned with national NCOP evaluation plans and adopts a logic chain approach that aims to devise a structured approach that helps to understand the evidence of what works (or doesn't work), in what contexts, for who and how. This report focuses on the evaluation of outcomes and impact with respect to the outreach participants, however, some process evaluation is also considered where insights are relevant to enhancing outcomes (Crawford et. al., 2017).

The ISL outreach logic chain comprises the background context, the resources to achieve the objectives, the expected outputs, the anticipated shorter-term results and the anticipated longer-term impacts (Figure 1). The context of ISL and details of the activities and resources have been outlined in the previous sections of this report.

The main output is the engagement of target KaMCOP learners and then their project work on completion of the activities. The inputs and outputs are linked to the expected outcomes through the assumption that, through participating in the programme, the young people would become more positive about their possible future education and career opportunities in STEM. In the short-term, it was anticipated that the course would have a positive impact on the participants' self-reported academic aspirations, behavioural intentions (what they intend to do in the future), perceived self-efficacy and attitudes towards STEM.

The aims of both programmes (Inspiring Minds and Summer School) were:

(1) Develop HE subject knowledge (STEM), including support for developing subject specific knowledge and technical skills;

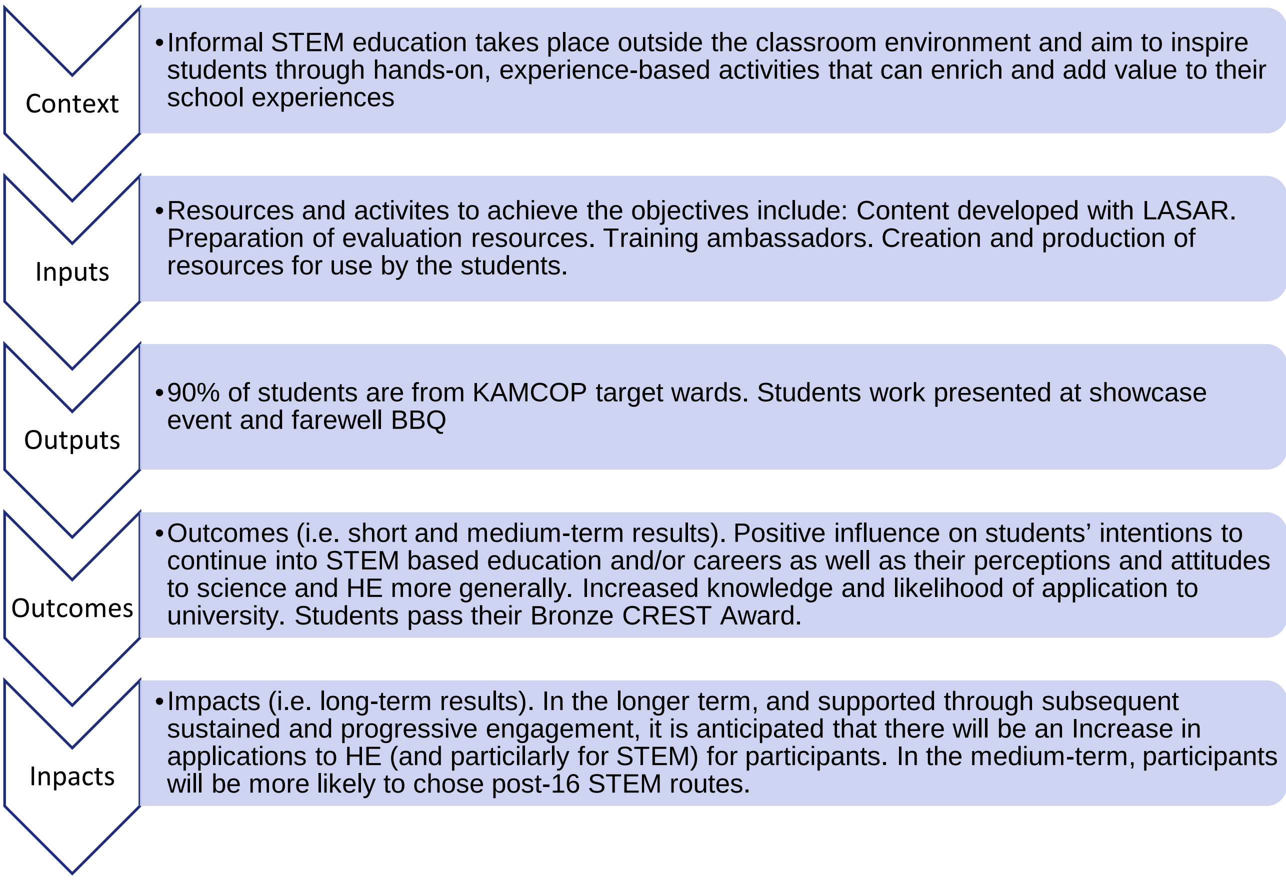
(2) Support and prepare students to make informed choices about their future;

(3) Support personal development.

Collaboration with LASAR provided a fourth aim to change students' perceptions of the nature of STEM by exploring it in real world contexts and multidisciplinary arenas (particularly examined via student interviews).

The objectives and the measures used in this evaluation are summarised in Table 2.

Figure 1 *Logic chain overview for ISL Outreach*



The evaluation plan was developed to investigate to what extent the activities could be said to have had an influence on the young learners through responding to the following questions:

(1) To what extent might the activities (informal STEM learning in out of school settings) influence the students' intentions to pursue STEM based education and careers as well as their perceptions and attitudes to science and HE more generally?
(2) To what extent could the activities be said to have influenced students' aspirations and sense of self?
(3) To what extent could the difference in the intensity of the activities (i.e. Inspiring Minds Saturday clubs compared to 4 day summer school) be said to influence the participants perceptions and attitudes (e.g. could one approach be said to be more beneficial?)
(4) To what extent is the underpinning epistemic insight pedagogy a contributory factor in changing students' perceptions of the nature of STEM learning and careers?

To evaluate the participants' sense of self, the questionnaires used measures for self-concept (an affective or emotional judgement related to a topic) and self-efficacy (a judgement about 'one's ability to organise and execute the necessary actions to attain a goal') (Beier *et. al.,* 2008).

Table 2
Summary of Objectives

Objectives	Measures
• Participation of KaMCOP ward learners and female students	• Over 90% of participants are from KaMCOP wards • Proportionally higher participation of females
• Participants to report an increase in their academic motivation and confidence	• Increase in level of agreement with statements relating to educational aspirations and motivation measured using repeated survey statements • Students are more likely to say they will apply to HE in the future, measured using repeated survey statements.
• Participants to report that they feel more positive about pursuing STEM related education and careers.	• Students are more likely to say they plan to participate in STEM in the future, measured using repeated survey statements. • Thematic qualitative evidence describing perceived benefits of participating in STEM outreach and how this might link with future educational and career options
• Participants to report that they can see the wider relevance of STEM	• Students are more likely to say they recognise wider social benefits of STEM, measured using repeated survey statements. • Thematic qualitative evidence describing perceived benefits of STEM in society and how this might link with their future educational and career aspirations
• Participants to report benefits to their perceived sense of self	• Students are more likely to agree to statements relating to self-concept in STEM and more general statements relating to self-efficacy, measured using repeated survey statements. • Thematic qualitative evidence describing perceived benefits of STEM outreach for building a positive sense of self.
• Participants to achieve a Bronze CREST award.	• Over 90% of participants to pass Bronze Crest

The methodological approach to evaluation was conceived around repeat measure surveys. The survey questions were firstly derived from the CFE Research baseline survey and questions were included that asked about: educational aspirations, knowledge of HE, likelihood of applying to HE, perceptions of HE, self-efficacy, and demographic questions such as whether they are first generation HE in their family, their gender and ethnicity. Qualitative data from the questionnaire were thematically analysed, guided by the 'benefits to ISL' themes from Wellcome Trust (2017) research (which consisted of interviews with young people). Baseline surveys were completed at the first session and follow-up surveys at the final session with all participants who were present.

Following, the initial evaluation of the first cohort of Inspiring Minds project, additional survey questions were included for Cohort 2 and the July Summer Schools to evaluate attitudes towards future participation in STEM, self-concept in STEM and the perceived societal importance of STEM (Table 3). These questions were derived from the 'attitudes towards science' measures developed by Barmby et. al. (2008). For these questions, sub-scales for: self-concept in science; future participation in science and the importance of science were modified to ask about STEM (not only science). Repeated measures were also included for perceptions of HE and self-efficacy. The repeated measures design used a post-activity survey (completed at the conclusion of each project), asked for feedback on the perceived benefits of the project, and included open questions to elicit qualitative feedback from the students on the impact of the sessions.

Table 3
Repeated measures survey questions

Variable	Statements
Educational aspirations	I am motivated to do well in my studies;
	I am confident I could get the grades I need for further study
	I am confident I could gain a place on a course of my choice if I wanted to
Self-concept in STEM	I find STEM subjects difficult (reverse coded)
	I am just not good at STEM subjects (reverse coded)
	I get good marks in STEM subjects
	I learn STEM subjects quickly
Future Participation in STEM	I would like to study more STEM subjects in the future
	I would like to study STEM at university
	I would like to have a STEM related job
Importance of STEM in society	STEM is important for society
	STEM make our lives easier and more comfortable
	The benefits of science and technology are greater than the harmful effects
	There are many exciting things happening in science and technology
Future Intentions	How likely are you to apply to higher education in the future?
Perceptions of HE	It is for people like me
	I would fit in well with others
	I have the academic ability to succeed
	I could cope with the level of study required
Self-efficacy	If I study hard I will get better marks
	I feel that I have a number of good qualities
	I am able to do things as well as most other people
	Setbacks do not discourage me
	I am a hard worker
	I finish whatever I begin
	I feel good about myself

Interviews

Interviews were conducted with 17 students from Cohort 1 of Inspiring Minds over two days. The initial interview cohort was chosen due to the school's willingness to engage with the associated research carried out by the LASAR research hub. Therefore, it is important to note that the students' perception of science learning in school may be indicative of a local rather than generalisable trend. However, the students do represent a range of formal science engagement and academic attainment and their attitudes towards formal science learning are comparable to large scale findings from previous research undertaken by the centre (and nationally). All the students who provided consent were offered the opportunity to take part in individual or paired interviews in the weeks immediately following the showcase.

The key organising member of staff was also interviewed during this period, and the continued engagement of the school with the outreach team provided the opportunity to interview one of the Deputy Head Teachers in the September following the programme providing richer data about the impact of the project in the short-to-medium term. The qualitative data was thematically analysed with extracts used to highlight the emergent themes. Contrasting results were identified where potentially rival explanations emerged.

Students for interview from Cohort 2 will be selected based on their responses to the surveys with the aim of ensuring a cross-section of students' attitudes and engagement with the project. Students who additionally take part in Summer Schools will be selected to be interviewed with Cohort 3 students in September 2019.

Results

Participation & data collection

In total, 212 individual young people were registered on the ISL activities with majority (140) taking part across the two Inspiring Minds cohorts (Table 4). Fourteen students completed both Inspiring Minds and a Summer School. Overall, 94% were known to be from KaMCOP wards and 57% were female. 94% were known to be from POLAR 3 Quintile 1. The ratio of females was highest for the second cohort of Inspiring Minds (80%) and for the mixed summer school (87%). The activities are targeted at year 10 students, and 95% were in year 10 at the time of the activity. The remaining students were in year 9 and year 11. The students were from fifteen schools throughout Kent and Medway and from a range of KaMCOP wards.

In terms of the survey data collection, 146 responses were matched for participants completing both the baseline and the follow-up surveys (Table 4). The number of matched surveys was lower than the total number of participants and the mismatch was due to either: students not consenting to share their data; participants missing the first or last session when the surveys were completed; or missing (or incomplete) details such that an accurate match could not be made.

Table 4 [2]
Summaries of survey data collected

Cohort	Registered Participants	Completed Baseline surveys[2]	Completed Follow-up surveys[2]	Matched surveys
Inspiring Minds Cohort 1 (Jan 2018)	68	50	42	35
Summer School July 2018 (mixed)	43	40	40	34
Summer School July 2018 (boys)	43	40	36	35
Inspiring Minds Cohort 2 (Sept 2018)	72	56	51	43
TOTALS	226[3]	186	169	146

Percentage of Inspiring Minds Students from NCOP target wards

	Not NCOP	KaMCOP	Sussex Learning Network	Total Students	% KaMCOP
Inspiring Minds 1	6	62		68	91%
Inspiring Minds 2	3	69		72	96%
Inspiring Minds 3	3	70	1	74	95%
All Cohorts	12	201	1	214	94%

Percentage of Inspiring Minds Students from Q1 (POLAR 3)

	(blank)	Q1	Q2	Q3	Q4	Q5	Total Students	% Q1 (POLAR 3)
Inspiring Minds 1	1	62	1	2	1	1	68	91%
Inspiring Minds 2	1	69	1		1		72	96%
Inspiring Minds 3		71		2	1		74	96%
All Cohorts	2	202	2	4	3	1	214	94%

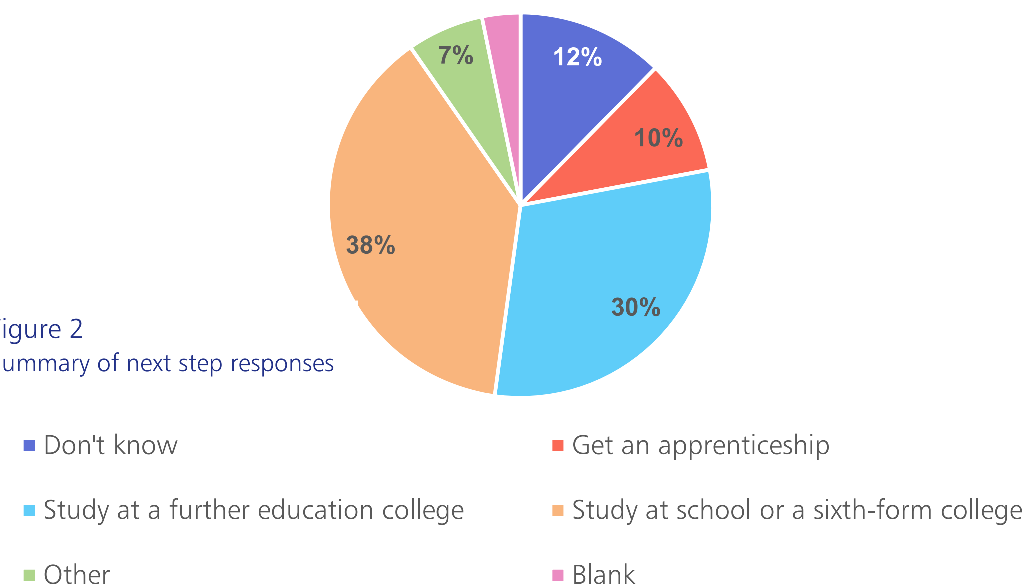


Figure 2
Summary of next step responses

[2] Inspiring Minds cohort baselines collected using CFE format and some students did not consent to sharing their data, hence lower completed baseline numbers. Also, some participants missed the first session but joined later hence lower baselines than total registered for Inspiring Minds cohorts.

[3]212 unique individuals, 14 students did both Inspiring Minds and a Summer School.

[4] The definition of first generation HE used means that they may have an older sibling who has already attended HE. 73% of known , of the data 16% did not know and 2% did not respond

Demographics

Baseline surveys were collected at the first session for 186 participants. 33% of participants did not know whether they would be the first generation in their family to study in HE. Of those that did know, 64% indicated they would be the first generation in their family to study in higher education[4]. In terms of ethnic identities, 85% of the participants identified as a white ethnicity (78% White-British), 3% of a mixed ethnicity, 4% as an Asian ethnicity, 2% as a black ethnicity, 3% as other ethnicities (the remainder preferred not to say or didn't respond). In terms of gender, 82% of the mixed summer school cohort was female and across the Inspiring Minds cohorts, 62% were female.

38% indicated that they would stay on at school (in sixth form) and 30% indicated they would like

to go to an FE college (Figure 1) after GCSE. Overall, 83% agreed that they were motivated to do well in their studies. However, the participants were less confident that they could gain a place on a course of their choice if they wanted to, with 66% agreeing. Three quarters of participants said they were either likely or definitely would apply to study in HE in the future.

Baseline Measures

Baseline attitudes to STEM were collected on the Inspiring Minds cohort 2 and at the two Summer Schools. The students were largely neutral (didn't agree or disagree) towards the three subsets of statements on self-concept in STEM, future participation in STEM and the importance of STEM in society. The highest agreement was with the statement that there are many exciting things happening in science and technology (56% agreed). The highest level of disagreement was with the statement 'I find STEM subjects easy' where 20% disagreed.

The responses shown in Figure 2 were numerically coded (where 1 = strongly disagree and 5 = strongly agree) and an average was taken for each of the three attitudes towards STEM subsets. These results contrast with the results from Barmby et. al. (2008) for younger year groups (Table 5). It is worth noting that this is for illustrative purposes only as the research from Barmby et al (2008) had a different methodology (e.g. it asked about attitudes to 'science' not STEM) and a different context to the present research.

The results from KaMCOP ISL (predominately with year 10 students) for self-concept and the importance of STEM in society were consistent with the trends identified in Barmby *et. al.* (2008). That is, these self-reported constructs are observed to decline as the students' progress through the school years. However, the results for future participation in science were higher, perhaps influenced by the application and selection of candidates with keener interests in participating in STEM in the future.

"I feel it's opened my eyes up to where I wanna go further in life, it's interested me more in robotics"

Table 5 *Summary of averaged responses to the attitudes to STEM[5] question subsets*

	Barmby *et. al.* (2008)			KaMCOP ISL
	Yr7	Yr8	Y9	Yr10
Importance of STEM in society	3.65	3.45	3.35	3.16
Future participation in STEM	2.60	2.55	2.45	3.14
Self-concept in STEM	3.70	3.60	3.60	3.46

[5] The Barmby study asked about attitudes towards science. Results are contrast for illustrative purposes only

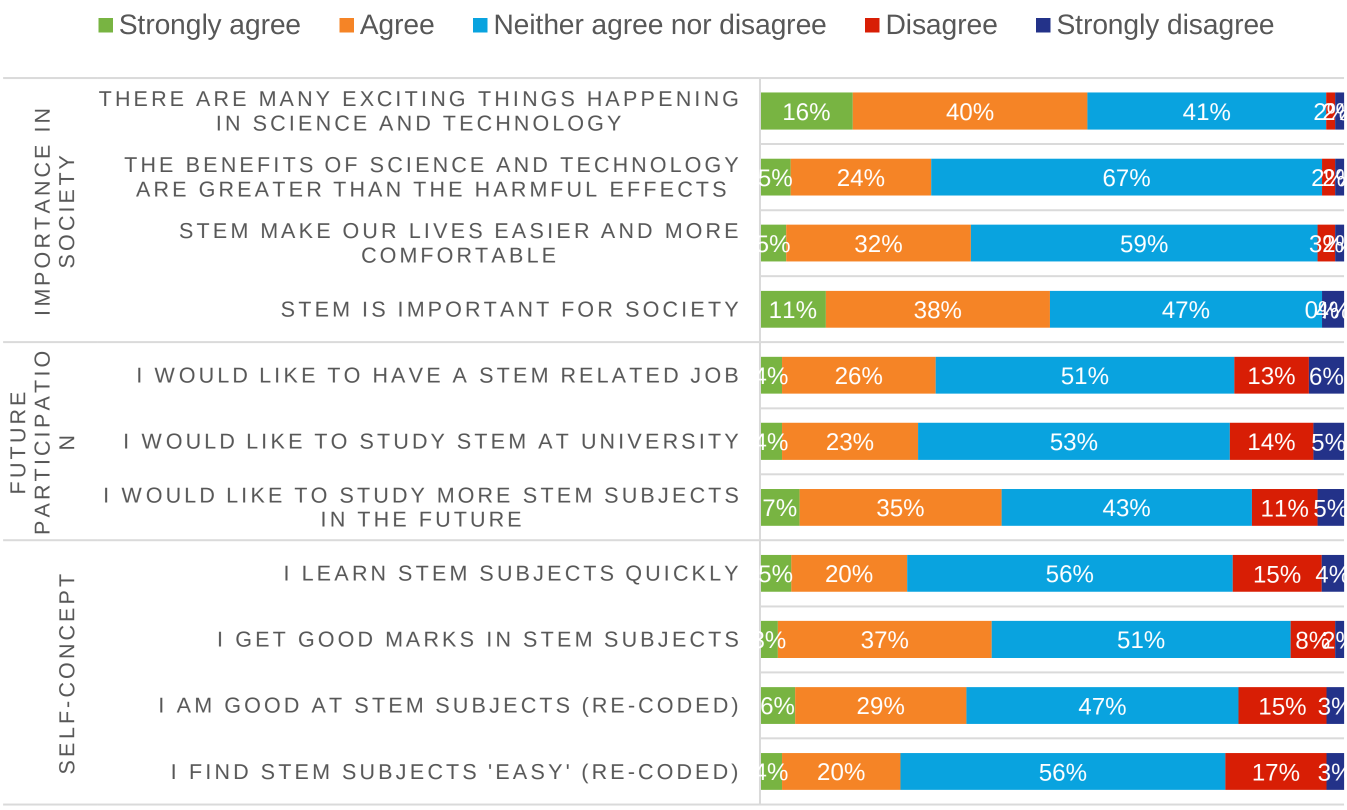


Figure 3
Baseline attitudes to STEM (only collected at Inspiring Minds Cohort 2 and Summer Schools)

Distance travelled – changes in attitudes

The interventions had the objectives of inspiring change in the ways that the young people perceived their abilities to participate in STEM as well as the potential societal benefits of engaging with the continually evolving challenges of STEM. As part of a theory of change, the analysis sought to understand whether changes in the young people attitudes could be detected and whether any changes (positive or negative) could subsequently be associated with the intervention (this is, changes were not random or would have happened in the absence of the intervention). The self-reported measures from the baseline surveys were compared with the self-reported measures from the post-activity surveys for each individual taking part and the pattern and magnitude of change were analysed for the entire sample to understand the overall trends.

Overall, 146 pre- and post-activity surveys were matched, based on Individual details across the two cohorts of Inspiring Minds and two Summer Schools. The 'attitudes' to STEM questions were matched for Inspiring Minds Cohort 2 and two Summer Schools (n=112), and educational 'aspirations' were matched for all four groups (n=146).

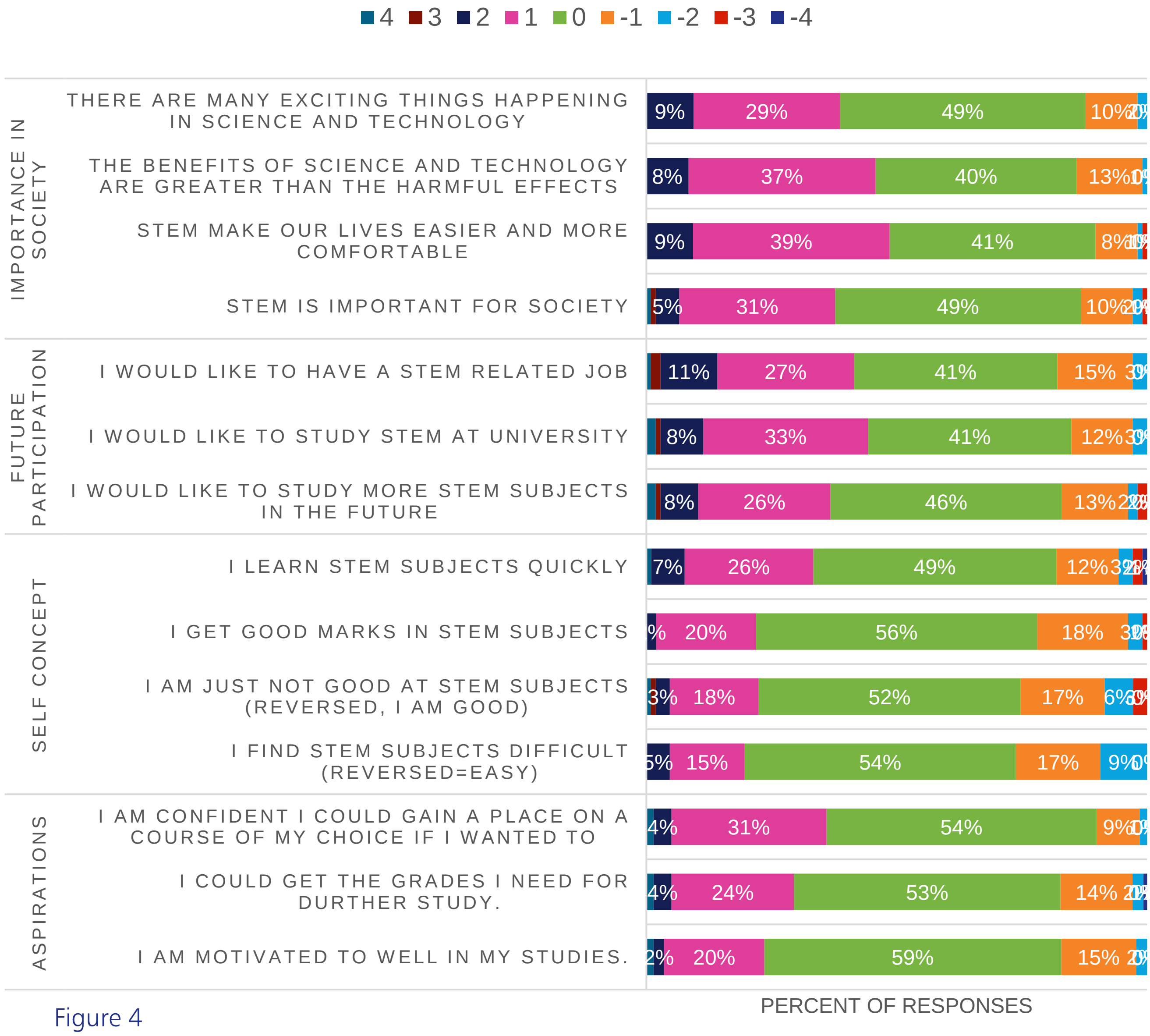


Figure 4
Summary of change in scores for matched individual responses

SPSS (Wilcoxon Signed Rank and Paired T-Test), the change in scores (mean scores and change in mean ranks) was measured. Results (see Appendix A for a summary of the results) showed a statistically significant change in all the statements within 'Importance of STEM in Society' ($p < .001$) however all had a small effect size ($d < .36$). Students also displayed a statistically significant shift in attitudes across the 'Future Participation in STEM' statements ($p < .008$) however again these all had a small effect size ($d < .28$).

Participants also displayed a significant shift in two of the statements related to Educational aspiration ('I am confident I could get the grades I need….' $p < .001$ and 'I am confident I could gain a place on a course of my choice if I wanted to' $p < .001$) again with small effect sizes ($d < .27$).

With regard to the variable 'perceptions of HE' (which links to case study 4), a significant, positive change in attitudes was seen across all four statements ($p < .002$). The effect sizes were small (>0.32) for the statements *'it is for people like me'* and *'I would fit in well with others'*. The likelihood of students applying to Higher education in the future also displayed a significant, positive shift ($p = .027$, $d = .12$).

The change in scores were not significant for all the 'self-concept' statements and the statement "I am motivated to do well in my studies". This motivation statement received a high level of agreement at the baseline (83% agreed) and therefore, there was minimal room for improving scores across the four groups. On the other hand, the self-reported responses to the 'self-concept' statements did show significant differences. The self-efficacy variable consisted of eight statements and there was a positive change in the responses for five of these eight statements. The effect size was largest for the statement '*setback do not discourage me'* ($d=0.21$). Based on the intensity of delivery (i.e. Inspiring Minds compared with Summer Schools), there was no difference in the amount of change in the scores for these two grouped variables.

Two independent variables, Gender and Intensity of activity (Inspiring Minds versus Summer School) were individually analysed for four dependent variables (self-concept, future participation, importance in society and aspirations) using both the independent t-test and the Mann-Whitney U-test. Analysis showed that there were no differences in the amount of change seen in scores based on these two variables between pre- and post- survey measures (consisting of the aggregate change in score for each statement associated with that variable).

Comparing year groups 7, 8 & 9 from a cohort of 932 students across five schools and 3 English regions, Barmby et, al. (2008) found that pupils' attitudes towards science declined as they progressed through secondary school, and this decline was more pronounced for female pupils.

Whilst the results are not directly comparable (due to both methodological and contextual differences), the results from KaMCOP ISL [7] showed that self-reported perceptions of the importance of STEM in society and of possible future participation in STEM were enhanced on completion of the outreach activities (Figure 5). The results for 'self-concept in STEM' were in line with the trend documented by Barmby et. al. (2008) at the baseline and were relatively unchanged on completion of the outreach activities.

[7] KaMCOP baseline data for Inspiring Minds Cohort 2 and both Summer Schools. Follow-up data for all four groups.

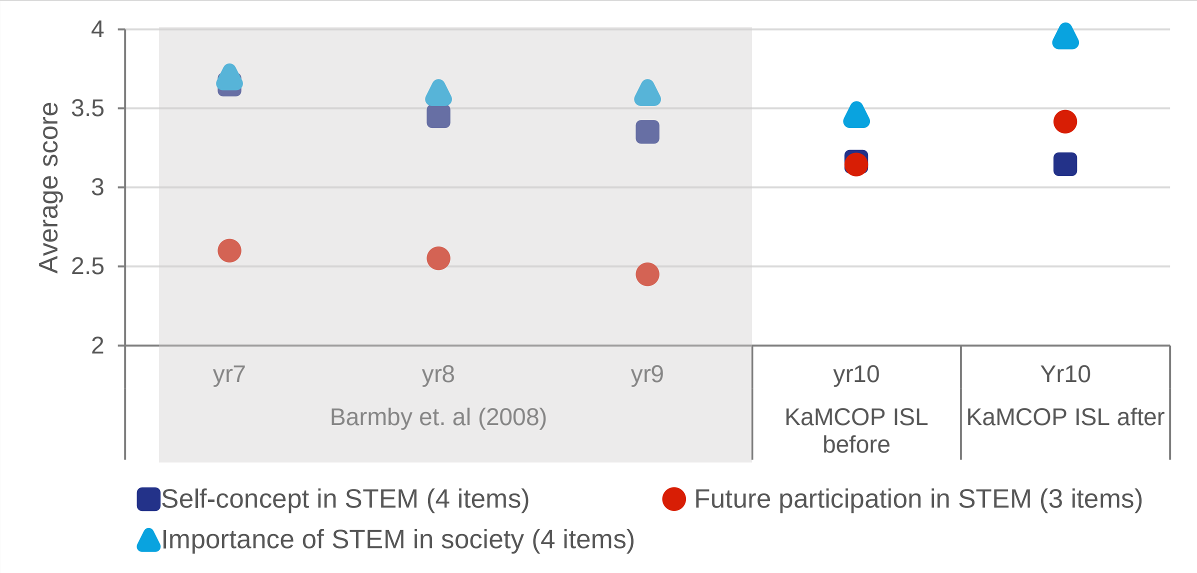


Figure 5
KaMCOP ISL – Changing attitudes to STEM

The variable 'perceptions of HE' consisted of four statements (refer Table 3) and there was a positive change in the responses to all of these statements (see Appendix A for results). The effect sizes were small (d < 0.35) for the statements *'it is for people like me'* and *'I would fit in well with others*'. The self-efficacy variable consistent of eight statements and there was a positive change (statistically significant) in the responses for five of these eight statements. The effect size was largest for the statement '*setback do not discourage me'* (d=0.21). Based on the intensity of delivery (i.e. Inspiring Minds compared with Summer Schools), there was no difference in the amount of change in the scores for these two grouped variables.

In summary, the data showed predominantly positive changes in the young peoples' attitudes that corresponded with their participation in the activities and the changes detected were outcomes that were anticipated through a theory of change. Moreover, the changes in self-reported attitudinal measures were consistent across a number of cohorts of young people who participated in activities during different semesters and different academic years. Although the benefits of participating in the activities cannot be confirmed through a control group of non-participants, the achievement of anticipated outcomes and the general replication of positive trends in attitude change over different groups of young people suggests an association with the interventions.

Additionally, 84% of the Inspiring Minds: ISL Students achieved their Bronze CREST Award, a key objective of the programme, raising attainment and changing perceptions of STEM and increasing knowledge of Higher Education and progression routes.

	Registered Students Session 1	CREST Awards passed	% Passed
Cohort 1	68	58	85%
Cohort 2	72	60	83%
Total	140	118	84%

Evaluative feedback

The feedback gathered via Likert-type statements indicated that the majority of the students felt they benefitted from the informal STEM-based learning (Figure 3), for example 79% agreed that they enjoyed taking part. The responses indicated that 77% of the young people taking part said they had been motivated to study STEM by the ambassadors (77% agreed) while 65% said they had been motivated by the academics. Feedback gathered for Inspiring Minds indicated that taking part had helped students feel more supportive about the benefits of science and technology in society (80% agreed). Whilst 60% agreed that taking part had helped them feel more confident in classroom discussions.

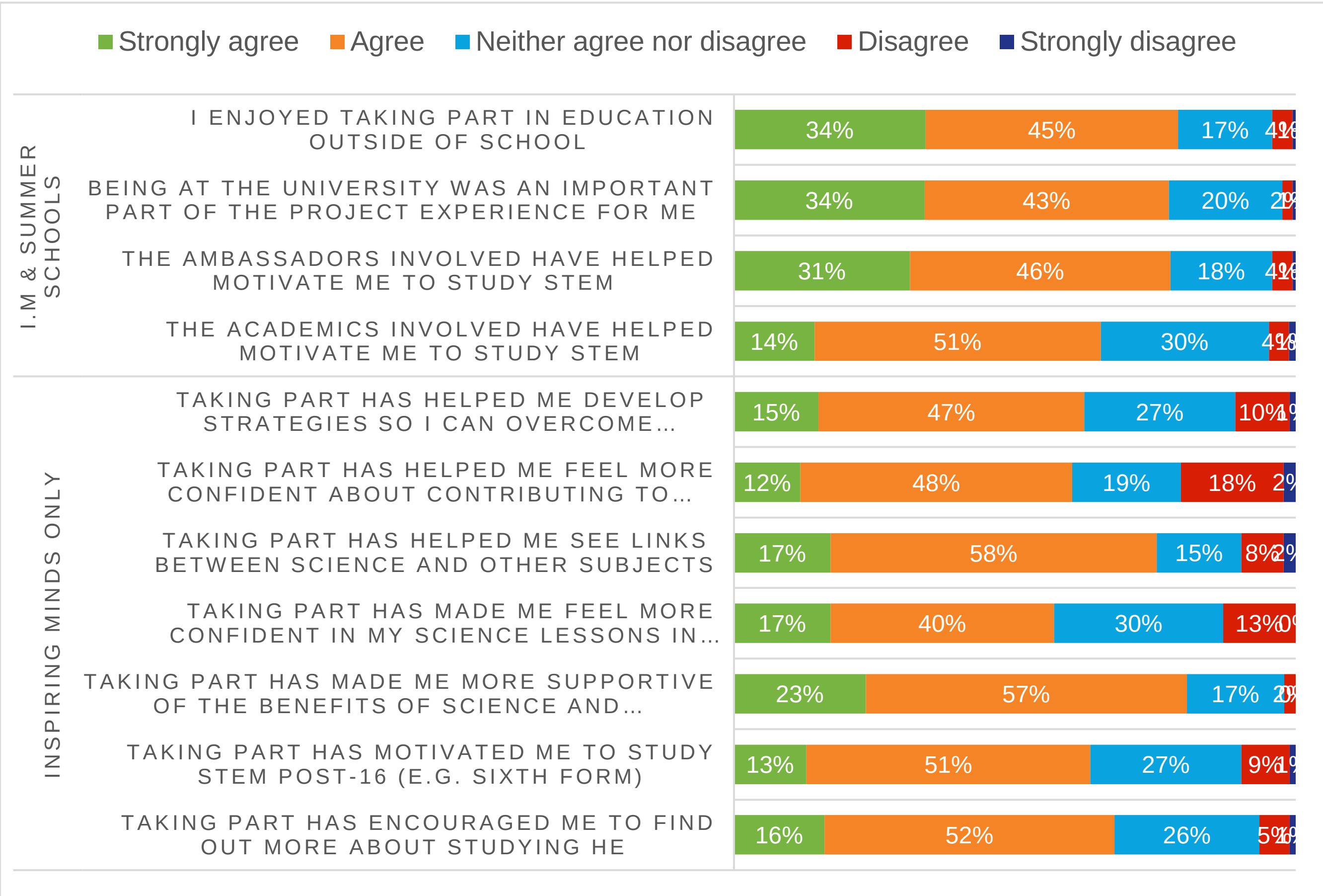


Figure 6
Feedback on the benefits of taking part in informal STEM learnin

For Inspiring Minds, the students responded positively to the sessions, in particular sessions 1, 2 and 6. Perceptions of sessions 3 and 4 were more mixed (particularly when contrast over the two cohorts). Responses to sessions 5 and 6 described how some students had experience positive boosts in their confidence through taking part.

The question "What brought you back to the Inspiring Minds sessions each month?", left itself open to answers for example, *'the coach'* or *'my mum'*. However, most of the responses indicated that they came back because of a mixture of the following:

1. The vouchers,
2. Wanting to achieve the Crest award,
3. For fun and enjoyment,
4. Wanting to finish the project,
5. For the experience,
6. For the teamwork and friendships,
7. Partnerships with the ambassadors,
8. Through obligation (e.g. *'the contract'*).

There was also some qualitative indication of perceived benefits to supporting attainment, for example, one student (Cohort 2) responded:

"Knowing that it would help my science grade because I want to be a vet"

and another (Summer School),

"The Bloodhound project helped me strongly with my physics".

The interviews enabled the question of motivation to be explored more thoroughly and also highlighted several students who had cited vouchers as having a big impact on motivation in the survey but gave more complex answers in interview such as

"it was to prove to my parents I could stick at something"

or

"I've always wanted to go to university and experience lectures and stuff like that because it was just something for me to think about because no-one in my family has been to university before".

A few students mentioned that the invitation to take part was a big motivator in engaging – it wasn't simply about the opportunity but to engage with ISL/HE but that "I felt wanted". The initial interviews with Cohort 1 students clearly highlighted the complexities of students' motivation and the challenge of running a sustained outreach project at weekends. For many students the vouchers served as the initial motivation to engage with the project, particularly where there was a hesitancy to engage with STEM or felt that there was need to

compensation for taking "*time out from our Saturdays*".

Additionally, the interviews highlighted that for students where FE and/or HE participation was already an aspiration (irrespective of attitude to STEM) a key motivator was the transferable value of their engagement with the project in relation to their CV or college applications. For some students who weren't already aspiring to HE, engaging with Inspiring Minds enabled them to have a university experience and a common theme for these students was opportunity as a motivating factor.

Finally, a key finding from the interview data was the shift in motivation from pre- to mid-participation when the majority of students who had been initially motivated by the financial incentive shifted to continuing to engage because of the curriculum content. Although further analysis needs to be undertaken with Cohort 2 these initial findings highlight the importance of combining an incentivised activity with a research-engaged curriculum that has been targeted to address identified barriers to engagement.

Perhaps of particular note were the interviews with students who attended both events [8] where they highlighted the symbiotic relationship between the two activities – one students noted that participating in Inspiring Minds had given them the confidence to attend a Summer School, and another it was the combination of Summer School and Inspiring Minds that had inspired their aspiration to attend HE:

[8] Not all students interviewed who attended both events were identified as such during the interview process, so this limits the current data set for this group. Additional interviews with Cohort 1 students known to have participated in both activities are scheduled for this year, and a deliberate sample of these students from cohorts 2 & 3 will be selected for interview (where possible).

"with the Saturday activities […] you learnt a bit more of the opportunities […] you might do in university […] whereas in the Summer School it's more or less living at the university" [student A];

"I didn't really think about university before but it's really shed a new light on it and I definitely want to go now" [student C].

The response to the questions: *"What has been the most valuable and/or useful thing you have learnt as part of the project? Why?"* and *"How would you compare your learning experience on the project with your learning experience at school?"* were explored to build up thematic understandings of the benefits to ISL that the young participants perceived. In Table 5, the main themes that emerged from the Inspiring Minds data are compared with themes from Wellcome Trust (2017) research (which consisted of interviews with young people).

There was consistency in the overlap of the results from this evaluation with the Wellcome Trust themes. In particularly, **teamwork** emerged as a strong theme across both the Inspiring Minds and Summer Schools, particularly in terms of the number of responses. There was also a range of sub-themes to 'teamwork', which included describing the benefits from 'collaboration', 'cooperation', 'shared responsibility' and 'appreciating other people opinions'. **Finding out about university** and the consolidating the possibility of going to university was a stronger theme in the Summer School data, for example:

"by talking to other students to find out their experiences to help me understand what uni is like and the path to uni".

Within the interviews from Cohort 1 repeated themes in discussion of the value of engaging with the project centred around opportunities to be in charge of their learning; undertaking a research project and/or the acquisition of transferrable skills. These benefits were also highlighted by Allchin (2013) as significant features in reforming science education. Whilst the research in this area is discussed in further detail in the research integration section of this report, there are points that are pertinent to make here as well.

Some students who viewed the opportunity for independent learning as the most valuable outcome of engaging with the project also noted that it had impacted on their learning in school as they had used the skills to complete (non-STEM) homework "*instead of just copying from the text book*" or that they "*hadn't been given something like that before so going away and looking at different sources*" and being critical in bringing the group's research together were new learning opportunities for the students.

The Inspiring Minds showcase (and preparing for it) was perceived by a number of young people for improving their confidence. The summer schools also supported students with building confidence, as was evident in a number of responses. There was also a possible additional sub-theme where participants described benefits to Learning how to cope - with stress, to not be nervous or scared.

For example students reporting in interview that *"I'm not really one to go up and talk but it's opened me up and I'm a bit more comfortable* […] *in talking to people about certain things"* (student O)*; "I was a bit nervous at first but then when you got in to it, it was easier"* (student I); "*it definitely helped me with my confidence* […] *being able to put myself out there more* […] *and I'd say I'm a lot better at working in teams* [than before Inspiring Minds]" (student H).

The Wellcome Trust's theme of '**Strategic Thinking'** (which summarised benefits of reflective and process-oriented learning) was not manifest in the data and the emergent theme was described as **"Understanding the broader context of science in society"**. The benefits described by the participants related more to the role of science and technology in society, for example:

"This helped me better understand the world around me and current technology."

and

"It shows how much the earth is in danger and that we need to do things to help the environment".

This theme is of particular interest as it is closely tied to the rationale behind underpinning the Inspiring Minds curriculum with an epistemic insight-led pedagogy. As with the previous theme this is expanded in more detail later in the report but it is notable that there was there was a strong recognition by students in Cohort 1 (and in informal discussions with Cohort 2 students) of a move in their understanding of the nature of science from the narrow concept-led experience at school to the real world, and career related opportunities in science beyond the classroom.

Students spoke to having gained an understanding of how much their daily lives are "*all linked with science"* (student Q); or that that science "*is something better than just sitting in a classroom learning because it had a bigger impact*" (student O) with this wider understanding of science also fuelling some students' aspirations to explore science beyond school

"its definitely allowed me to look at new job opportunities" [they didn't realise were STEM-related] (student H).

Another Wellcome Trust theme was **'Creative Skills'**, where the young people had highlighted benefits to being creative and having the freedom to explore ideas. This was contrast with the 'Strategic Thinking' theme where they had highlighted their enjoyment of the creativity behind an activity rather than the systematic building or doing something. This theme was not evident in the data, based on the responses to "*What has been the most valuable and/or useful thing you have learnt as part of the project"*. However, when the participants were asked, *"How would you compare your learning experience on the project with your learning experience at school?"* many highlighted how they preferred learning in the outreach environment. There was some concordance with the creative skills theme, particularly around ideas of:

independence

"At school we rely on the teachers, whereas in these sessions we're independent",

freedom

"you're more free and can use your own ideas"

fun

"This was WAY more fun and Practical".

As noted above freedom and independent learning were noted by students in interviews as being key drivers in changing their perceptions of science, and (for some) education at FE and HE level

Initial Interview Analysis

The interviews were undertaken to develop a greater understanding of the educational impact of participating in ISL that used big philosophical questions raised by science and technology as a way to engage students. Through understanding the engagement with ISL it is hoped that we can develop a deeper understanding to the barriers of under-served audiences in engaging with STEM in the formal learning context. Four key themes arose from the student interview data (a) students engaged with the opportunity to undertake independent learning; (b) students' engagement with science through the lens of big philosophical questions; (c) how the style of the science education differed substantially from "school science" and (d) the impact the programme had on their interest in HE.

Independent learning and/or freedom were mentioned explicitly in nine of the interviews. Students frequently commented on the achievement or enjoyment of having the freedom to "do our own research and find out our own stuff" which was often placed in comparison to school science that is "just copying out of a textbook" or "exam style questions you've gotta do it like this, this is the answer, this is the wrong answer, you don't really get to have your own opinion" with one student going as far as saying "I found it easier [on Inspiring Minds] because we weren't being spoon fed but were given the information in ways we understand". For some students The lack of a single answer or method was one of the most challenging aspects of the programme and it was this change in their understanding that there can be multiple perspectives or answers which they took through in to their learning in school. Students' perceptions of the value of independent learning was often linked to the "recipe investigation" approach to school science, and whilst the CREST award facilitated the independent learning that for many students was a positive experience. The opportunity for students to engage in independent learning was also drawn out in the staff interviews that one of the anticipated gains for students was not just meeting the grade but

"*that thinking, it's not just chalk and talk and regurgitation at GCSE […] having the confidence to criticise and analyse in the exam*".

With the SLT staff member noting that the draw to participate in Inspiring Minds was that it was

"*an excellent project for introducing student to higher level thinking and empowering them to be able to access material they wouldn't have normally thought they could*".

Students were asked about their experience of engaging with big philosophical questions in both the workshops and as part of their CREST award and the response from the majority of students was an overwhelming enthusiasm for investigating science in this way (in comparison to their experience of school science). 11 students specifically referred to a preference for exploring science in a philosophical and multidisciplinary way and many felt they would be more engaged in science if it was taught in this manner.

"[science] i*s very different* [at Inspiring Minds] *like you get more opportunities and experiences like to explore different aspects of it* [science] *"*.

Students reported greater understanding of the relevance of science as a result of seeing its relevance to big philosophical and real-world questions and being challenged by the diversity beyond physical sciences:

"because this has proved what science actually is, because in school that's what I know science as but then this expanded on what science is and that I enjoyed that part";

"like science is so big and I'd never even thought of robots being anything to do with science but it is".

Closely linked to students' engagement with big questions was the comparison with the recipe investigations and engineered narrowing of what is amenable to science through school teaching. Particularly notable were the students who self-defined as "not science" students but who enjoyed the science experience at Inspiring Minds.

"I found it a lot better than like school 'cause you can open up so much more different things with it […] like I'd have to maybe bring some maths in to it for some reasons or like some English just to like look at it from a different perspective".

Many students viewed school science as being about "facts not questions" and that the content/concept focused science curriculum didn't allow them enough opportunity to gain a deeper understanding about understanding how things work

"I prefer to do more looking into how things work, but that's the same with science I'm just not very good at science".

For many students the opportunity to engage with university style learning on campus and/or ISL has impacted on their engagement with HE opportunities and future career choices. This was evidenced across students who only attended the Inspiring Minds programme as well as those who attended both Inspiring Minds and the summer school. For some students the interest in HE has come through the session topics

"I feel it's opened my eyes up to where I wanna go further in life, it's interested me more in robotics".

Whereas for other students it was the experience of being on campus and/or speaking to the ambassadors "*It's made me want to go to university even more*"; "*I think the ambassadors were really motivating to do it* [go to university]". For students that also took part in the summer school they felt that the combination of Inspiring Minds and the summer school provided a joined up experience of university life *"with the Saturday activities you learnt […] a bit more of the opportunities […] you might do in the university and all the resources that are available to you whereas with the summer school it's more or less like living at university"*. With some students expressing that without the opportunity to be involved in Inspiring Minds and the school encouragement to take the 'next step' they wouldn't have considered summer school *"I didn't really think about university before but it's really shed a new light on it and I definitely want to go now".*

The staff responses to motivation in engaging with the Inspiring Minds mirrored those of the students in many ways, with the wider experiences and development opportunities acting as a key driver to engaging with the project. The multidisciplinary nature and framing of the project around big questions were raised by both staff as important anticipated gains for their students.

"The *opportunity to broaden horizons and then the fact it was engaging with some big questions that involved interdisciplinary work, because this transfers back in to school and they hopefully start to see the subjects as less separate*";

"*for year 10 before it gets into focus on exams […] a last opportunity for them do this bigger thinking which they really need particularly for the new specification GCSE* […] *those analytical and evaluative skills".*

Staff also reported that students appeared to have had a build in confidence and helping their peers and explain their experience of university to others. This was particularly striking in the interview undertaken with SLT in September where they reported that students who took part in the previous two terms (now in year 11) seem very determined and much more aware of the opportunities when they leave school and "*greater awareness of themselves and what they're capable of*" and that seemed to have a big impact both during the programme and on their behaviour as they have come in to the new school year.

Next Steps

With the majority of interviewed students self-describing as disengaged from science within the formal school setting yet expressing motivation and engagement with STEM in real world and multidisciplinary arenas (through big philosophical questions) and disappointment/frustration that they're "*still always doing this kind of science* [school science]" (student D) and "*that's not what we do* [in science] *in school*" (student F), the initial research highlights the importance of sustained STEM/ISL outreach underpinned by an epistemic insight pedagogy.

If Big Questions do indeed act as hook for student engagement and it acts as a motivating factor for further STEM engagement, students need to be supported to continue to develop their interest and understanding of STEM beyond their experience of the National Curriculum. These projects (ISL Summer Schools and Inspiring Minds), particularly when taken collectively, offer students a genuine opportunity to develop their understanding of the nature of science (and STEM related careers) that captures those students not being served by the current curriculum. Particularly important is that it offers a safe (non-grade bearing) space in which students can participate in student-centred and student-led STEM learning.

Whilst the curriculum design was developed in light of LASAR's research with secondary school students, the independent learning, modes of thinking, and bridging questions that students identified as helpful, echo findings by the Higher Education Academy (HEA, 2015) and the Royal Academy of Engineering (RAE, 2014). The engineering habits of minds identified by the RAE include the ability to make interconnections and use the varied perspectives and knowledge of team members to arrive at a solution. The project curriculum enables these traits to be developed or identified by students as relating to the nature of engineering and the CDIO approach in engineering education and industry and in doing so offers the potential to support these students into a more informed approach to participating in STEM HE.

The HEA report identifies key pedagogical principals that underpin high-impact student engaged learning within HE such as 'real world mapping of ideas', students being guided to independent enquiry and STEM learning placed in a meaningful context where students can see the present challenge relating to future applications. What this speaks to is the need to develop methods and opportunities to increase the sustained nature of the engagement and develop ways to bridge the informal outreach experience and the formal experience within schools.

In order to develop this further one of the next steps is to gather repeat data from Cohort 1 students to see if the positive attitudinal shift has been maintained once students have returned to the school environment. Another is to investigate ways to take the Inspiring Minds experience in to schools to help to bridge the difference between the ISL and formal experience of science. This will also enable a more nuanced picture to be developed of the impact of being based on campus and if targeted support for science teachers can help to raise the aspirations and STEM self-concept in target wards.

Whilst analysis of the Cohort 1 results is ongoing and will be augmented with further interview data from Cohort 2, the initial analysis highlights the importance of outreach activities being underpinned by a targeted, developed and researched curriculum model. Particularly pertinent is the disparity between school students' experience of ISL and the reported didactic and narrow approach to science education in school. Whilst we are aware that the project is not designed to influence the science curriculum, or ITE provision, it is important to recognise the influence of the curriculum on students' motivation and engagement. Particularly in STEM where science capital is so crucial to students' aspiration and understanding of the discipline(s) outside of the educational context the outreach work needs to not only challenge students' misperceptions but also offer repeated and developmental opportunities to continue to engage target students as they hit key educational milestones. This raises the issue of whether a next step should be to adapt Inspiring Minds so that it can be modelled in Key Stage 3 prior to GCSE option choices. The results of this interim evaluation report have fed into the delivery and design of curriculum for Cohort 3 of Inspiring minds.

Table 5

Perceived benefits of Inspiring Minds compared with Wellcome Trust research

Wellcome Trust (2017) themes	Emergent themes	Cohort 1 examples
Learning about specific scientific processes	Learning about specific scientific processes - Developing knowledge and skills. This was particularly for learning about optics in Cohort 2.	*"Probably making the chat-bot, because I learnt how to code and it might be something I want to do as a job when I'm older."; "I have learnt a lot about the brain and eye and how it functions"*
Perseverance	Perseverance - Dedication towards achieving something.	*"That with dedication you are able improve and do well." "We dedicated ourselves to the project - and out of my comfort zone."; "it was to prove to my parents that I could stick at something"*
Teamwork	Teamwork - The importance of teamwork (including cooperating and collaboration), connecting with people and friendships.	*"Communicating with people and making friends";* *"the [CREST] question was perfect for our group[…]it was a really hard question[…] but we all knew little bits about it and we all had our own ideas and shared them"*
Confidence	Confidence - Building confidence.	*"Building my confidence";* *"it definitely helped me with my confidence[…] especially working towards the CREST awards to be able to present my own project[…] being able to put myself out there a bit more"*
Strategic thinking	Understanding the broader context of science in society.	*"This helped me better understand the world around me and current technology.";* *"this has proved what science actually is […] this expanded on what science is* [from school science]*"* *"like science is SO big and I'd never even thought of robots being anything to do with science but it is"*
Creative skills	Freedom of expression and independence.	*"You are able to express yourself even more without someone telling you, you can't."* *"the freedom to be able to study, where we we had a choice of what we got to study"*
	Learning how to cope - with stress, to not be nervous or scared.	*"How to cope with stress"* *"got me thinking about things I can do to de-stress myself instead of punching things or shouting"* *"quite helpful I think cause I was kinda helping us think about coping with exam stress"*
	Experience of university - Motivation to go to university. This was particularly evident for the Summer Schools and a recurrent theme in the interviews from Cohort 1.	"I didn't really think about university before, but it's really shed a new light and I definitely want to go now"; "it enlightened my sense of going to university more"; "[opportunity to] *go to university and experience lectures and stuff like that […] it's made me want to go to university even more"*

Cohort 2 examples	Summer School examples	Commentary
"Learning about optical illusions was most valuable"	*"The Bloodhound project helped me strongly with my physics"*	Many students were positive about the specific things that had learnt. Whilst creative skills were not mentioned, the development of skills was perceived as a benefit.
	"It gives support and enjoyment, and encourages hard work"	Many students commented that the benefits they felt from dedicating themselves to the project.
"Talking to new people who I never knew and also having this experience and what it's like to do a group project."; "I think team work, we were able to help each other and work as a team."	*"I think the most useful skill was learning how to comfortably communicate and work with other people"*	In addition to developing more positive perceptions of the benefits of teamwork, some also saw benefits to connecting with people and developing friendships.
"To speak to others more confidently"; "The most useful thing was taking part in the showcase, it helped me gain confidence and interact with ne people"	*"Talking to new people. I now find it easier to approach people and have a confident conversation."*	The benefit of building confidence was cited by a number of the students.
"That robots are changing every time people find something now out. This was the most useful thing because I know how things could change"	*"Most things link to science also you can go to university even if you're not rich"*	Strategic thinking was not a benefit explicitly cited by the students. However, other responses showed how the students were developing their understanding of the linkages of what they learned with broader social challenges. Thus, the theme of 'strategic thinking' might be better described from this data as 'understanding the broader social context'
"Inspiring minds is better as it helped me understand science in a fun way"	"I prefer this because it's more interactive and less restrictive"	'Creative skills' were not raised in response to what the participants thought was most valuable. However, when compared with learning in school some identified perceived benefits of more freedom, independence and fun.
	"That being nervous when everyone is in the same situation, is quite pointless."; To not be scared to talk to others and share ideas	Possible sub-theme to 'confidence'
"Seeing what Uni is like which has now made me want to go to Uni"	*"by talking to other students to find out their experiences to help me understand what uni is like and the path to uni"*	Could be a sub-theme to 'strategic thinking' in terms of thinking more strategically about possible options and the potential of university. Also thinking about how STEM links to careers and education opportunities.

Conclusion

The present document is an interim evaluation report of two projects launched by Canterbury Christ Church University as part of their KaMCOP offer. This form part of a response to the government aim to widen participation of students from selected, under-represented groups in higher education. The projects consisted of a series of six, sustained Saturday STEM clubs called Inspiring Minds: ISL and two residential ISL Summer Schools. The projects were created in collaboration with the LASAR Centre at the University and centred on an ISL curriculum. The aim of the ISL curriculum was to encourage and enable students to engage with difficult philosophical questions raised by current technological advances. It was an additional aim to see if whether ISL could affect attitudinal changes towards STEM and science education as well as attitudes about HE more generally.

The ISL activities inspire students through hands-on, experience-based activities that can enrich and add value to their school experiences. The curriculum focussed on knowledge generation to given students some form of science capital to engage them in STEM learning.

Previously we outlined our objectives for the two projects (Table 2) under pinned by the following questions:

a. To what extend might the activities (informal STEM learning in out of school settings) influence the students' intentions to pursue STEM based education and careers as well as their perceptions and attitudes to science and HE more generally?
b. To what extent could the activities be said to have influenced students' aspirations and sense of self?
c. To what extent could the difference in the intensity of the activities (i.e. Inspiring Minds Saturday clubs compared to 4 day summer school) be said to influence the participants perceptions and attitudes (e.g. could one approach be said to be more beneficial?)
d. To what extent is the underpinning epistemic insight pedagogy a contributory factor in changing students' perceptions of the nature of STEM learning and careers?

We were successfully able to achieve and answer all the objectives and above questions.

1. Participation from KaMCOP ward learners and female students

In total, 212 student part in the various ISL activities on offer. Of that that took part in inspiring minds 94% were from a KaMCOP target ward and 94% were from Q1 (POLAR 3). This highlights the highly successful targeting of this particular programme. Of those attendees at Summer School, 100% were from a KaMCOP target ward.

2. Participants to report an increase in their academic motivation and confidence

Evaluation showed that after taking part in the activities the aspirations of learners regarding HE improved greatly. 64% agreed that the activities left them feeling motivated to study STEM post-16 and 68% agreed that taking part encouraged them to find out more about HE. Qualitative data also suggested new confidence surrounding HE:

> "I didn't really think about University before but it's really shed a new light on it and I definitely want to go now"

Qualitative data from the questionnaires also explored students Experience of University and themes around *Confidence* and *Freedom of expression and independence* may contribute to future applications to HE and greater understanding of HE. The post-activity interviews also highlighted that students who attended these activities left feeling differently about HE and wanting to apply to university in the future.

Whilst the results were encouraging, the extent to which the activities could be said to have influenced the students' attitudes would be better understood through counterfactual analysis with data from similar students who didn't take part in the STEM interventions.

3. Participants to report that they feel more confidence about pursing STEM related education and careers

The evaluations showed statistically significant improvement in measure related to future intention to participate in STEM (whether in HE or at work, $p < .007$), perceptions of HE ($p < .012$) and intention to apply to university ($p < .027$). These results show that the Inspiring Minds approach has significantly impacted aspiration. The changes were however of a small effect size, so the extent to which ISL activities can influence intentions appears, at this point in time, to be small. However, with refinement to the programme it is hoped that this effect size can be moved from small, to medium.

In relation to the qualitative data collected by the questionnaires, the themes of *Learning about specific scientific processes* and *Understanding the broader context of science in society* also support the claim that these ISL activities impacted student's attitude towards STEM. The interview outcomes reported in the above strongly indicated that following ISL participation, students had a greater understanding and appreciation of the impact of STEM and science in the real world.

4. Participants to report that they can see the wider relevance of STEM

75% of learners indicated that they felt the projects helped them understand the links between science and other subjects with 80% indicating that the projects made them more supportive of the benefits of science. Across all four measures related to the importance of STEM in society there was a statistically significant change for the positive (Appendix B).

The results supported the hypothesis that explaining the wider context or applications of science would associate with students' interest and perceived utility of science, which fits in with implications from contemporary research and funded STEM programmes. For example, evaluation of the STEMNET programme that ran 2011-15 (Straw and Macleod, 2015) showed the benefits of the programme on informing young people perceptions of the importance of science for everyday life. They also found that the greatest impact was achieved where pupils had multiple engagements with STEM ambassadors and/or regularly attended a STEM Club. Furthermore, innovative teaching approaches are liable to rekindle interest in STEM and have a positive influence on young people's attitudes, particularly where there is high quality content and inspiring implementation (Savelsbergh et al., 2016). Such mechanisms of change are consistent with the type of outcomes measured in the present report. There are also similar patterns of results that are consistent over the four groups reported on here (Inspiring minds cohort 1 and 2 and the two ISL Summer Schools) that ran at different times in the school year and with participants for a range of schools and geographic regions in Kent and Medway. Therefore, although the positive benefits cannot be confirmed through a control group, the replication of results does support their validity.

5. Participants to report benefits of their perceived sense of self

57% of students felt more confident in science lessons and 60% felt more confident contributing in lesson as a result of the programme.

Regarding impact on self-concept, results showed no significant changes in respect to self-concept in STEM but did show positive significant changes, although with a small effect, in 5 measures of Self-Efficacy (Appendix A), particularly around finishing projects, feeling equivalent to others and not being discouraged by setbacks. We propose that by completing the CREST award alongside the rest of the cohort, students begin to see themselves as confident scholars who can overcome challenges (also see research showing the marginal benefits of undertaking a Silver CREST award, Pro Bono Economics Research, 2016)..

Self-concept in STEM is likely to be influenced by the complex interactions of a number of factors that include; interest and achievement (cyclically related); causal attributions (e.g. what students attribute success or failure to); reflected appraisal (e.g. how students think others perceive them); and external (e.g. comparing one's own abilities to peers) and internal (e.g. comparing one's own different abilities) frames of reference (Beier *et. al.,* 2008). It is likely that it would take a much longer period of time, and several types of activity to change self-concept around STEM. However, qualitative questionnaire data showed perseverance and learning how to cope with stress where key concepts that students came away from the sessions with, which would indicate the beginnings of change in their levels of self-concept.

In terms of the young people's attitudes towards STEM, the results from KaMCOP ISL for self-concept and the importance of STEM in society were consistent with the trends identified in Barmby *et. al.* (2008). That is, these self-reported constructs have been observed to decline as the students' progress through secondary school. However, the results for future participation in science showed a higher starting point than the Barmby study - perhaps influenced by the application and selection of candidates with keener interests in participating in STEM in the future. Whilst the results are not directly comparable (due to both methodological and contextual differences), the results from KaMCOP ISL showed that self-reported perceptions of the importance of STEM in society and of possible future participation in STEM were enhanced on completion of the outreach activities (and that the increase was not different between the males and females taking part). On the other hand, the results for 'self-concept in STEM' were in line with the trend documented by Barmby et, al*.* (2008) at the baseline and were relatively unchanged on completion of the outreach activities.

6. Participants to achieve a Bronze CREST award

Of those students who started Inspiring Minds: ISL 84.% achieved their bronze CREST Award.

When considering the influence of intensity of activity on the extent to which attitudes and perceptions are changed, results indicated that there was no significant difference in the level of change from baseline to post activity between the lower intensity programme (Inspiring Minds) and the higher intensity programme (Summer School). This suggests that the effectiveness of ISL is not dependent on how intensively it can be delivered which may be beneficial for schools when considering how their student may access such a project.

The ISL outreach was university campus based and there is some evidence that on-campus outreach can be more beneficial in terms of future progression into HE when compared with school-based outreach (Doyle and Griffin, 2012). However, this is also dependent on the students' prior attainment and may be less influential for higher attaining students (HEAT, 2018). The young people were incentivised to take part in Inspiring Minds, and therefore it could be expected that this would help them have a more positive experience. However, the young people also responded that: wanting to achieve the CREST award, fun and enjoyment, completing the project, the teamwork and friendships, and the ambassadors were all factors influencing their continued participation.

These motivations were similar for the Summer School (which was not incentivised) and across all participants, 79% agreed that they enjoyed taking part in the ISL outreach. Whilst boosting HE progression rates for these young people from NCOP wards is one aim of the programme, the first cohort of year 10s, who completed Inspiring Minds in 2017/18, will not be HE ready until 2021/22. Therefore, it will not be possible to evaluate their progression into HE during the current lifetime of NCOP (Phase 2 finishing 2020/21).

The themes that emerged from this research on the perceived benefits of ISL were similar to those from the Wellcome Trust (2017) study, however, learning ways to cope with stress was unique to this evaluation. The young people also discussed benefits to their confidence and communication skills, which are important soft skills that can help young people prepare for their future (Princes Trust, 2017). Whilst, the self-reported responses to statements about 'self-concept' remained relatively fixed over time, there was more shift in statements relating to 'self-efficacy'. The present research found statistically significant, positive changes in self-reported responses to the repeated self-efficacy statements, although they carried a small effect size. Although these two constructs are similar, self-concept judgements tend to include an affective judgement related to a topic whereas self-efficacy is defined as a judgement about 'one's ability to organise and execute the necessary actions to attain a goal' (Beier *et. al.,* 2008). As previously stated, self-concept around STEM is affected by many factors and is likely to require a more multi-faceted approach in order to change.

It is important to note here that as the groups of statements used for this evaluation have not been well-established or validated it is not possible to draw more meaningful conclusions from these results. It should also be noted that methodological biases such as social desirability/acquiescence bias (the tendency to try to anticipate the 'right' answer) or a placebo effect (awareness of being evaluated) might influence the self-reported measure, including the high starting points (Harrison *et. al.* 2018). Moreover, attitudinal change shifts cannot be directly attributed to the intervention without knowing what would have happened in the absence of the intervention (i.e. a counterfactual group).

When we consider the results of the interviews that were conducted post activity in response to question 4, students really enjoyed the opportunity to engage with science through big philosophical questions where they felt theory were less 'spoon fed' and enjoyed the freedom of working independently and being able to form their own opinions about these wider topics.

Students consistently compared the form of science learning in the projects, ISL, with 'school science'. Students felt that ISL showed them how broad Science is and how maths and English can also be a part of that learning reflecting back on the wider context of these issues around epistemic insight. This suggests that there is scope for the results of this interim report and wider research around ISL to inform science education in school to incorporate other subjects and real world contexts.

Interviews also indicated that the activities had influenced how students felt about HE in general and their intentions to study at University later on in life. It also appears that engagement with current students at the university was one of the motivating factors around new considerations of HE. This indicates that these activities fed back to the wider government aims to increase participation in HE from the low participation groups these programmes were designed for.

This in an interim report that will be updated as further data becomes available and as more cohorts complete the programme. Cohort 3 of Inspiring Minds began in March 2019 and is due to Finish in June 2019, with a further two ISL summer schools planned for July 2019 (Year 10 mixed and Year 12 Girls). Data from these activities will feed into a refreshed evaluation in the autumn. Future evaluation will investigate the possibility of including a control or counterfactual group to compare attitudinal outcomes and outcomes in terms of post-16 subject choices and ultimately, He progression, including progression into STEM when the young people are HE ready. Furthermore, the analysis will consider the plausibility of a retrospective, quasi-experimental analysis to investigate whether taking part in KaMCOP ISL impacts on the participants STEM GCSEs once that data is available.

In conclusion, the two ISL projects developed and delivered by the KaMCOP team at Canterbury Christ Church University have been shown to significantly improve academic motivation and confidence as well as feeling confident about STEM related careers and education. Students were also better able to understand the wider relevance of STEM and reported a positive increase in their perceived sense of self. This results affirm the curriculum and aims of the programme for future cohorts.

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Recommendations

- The sustained nature of Inspiring Minds and ISL Summer School provides the opportunity to capture, inspire and encourage students to engage with STEM/STEM-related subjects. The sustained nature of the project is crucial to continue as it enables students' misperceptions regarding STEM to be challenge and provides them with an opportunity to build their science capital in a way that isn't possible with one off or "parachute" activities. The next step for this project is to develop the sustained nature of the intervention further through:

    A. Rebranding summer schools under the Inspiring Minds umbrella e.g. Inspiring Minds: Residential

    B. Provide opportunities for students to engage with Inspiring Minds in school time with Inspiring Minds: roadshow

    C. Providing opportunities for students to engage with specialised Inspiring Minds programmes in years 11-13 e.g. Inspiring Minds: Medicine, Inspiring Minds: Engineering, Inspiring Minds: Sports Science

    D. Developing an Inspiring Minds: Junior programme for KS3 (mid-term) and KS2 (longer term)

  These developments will enable students to engage with ISL throughout their school career and in doing so offer opportunity to Inspiring Minds to build their science capital in a similar way to their more advantaged peers. The addition of specialised programmes will enable students to be directed on from Inspiring Minds in a meaningful way that enables aspiration and encourages HE participation.

- The engagement in ISL via 'Big Questions' not only allows for the opportunity to challenge misperceptions but, anecdotally, can also act as a driver for re-engaging students with their formal science learning in schools. However, in the current format students are leaving Inspiring Minds engaged with science in "real world and multidisciplinary contexts" but often still feel disengaged or worse let down by their experience of science in school, where it maintains its subject silo and is content rather than context heavy. Whilst ISL cannot change the science curriculum it can actively support it through:

    1. The delivery of Inspiring Minds: Roadshow sessions in schools
    2. The production of an Inspiring Minds teaching resource pack that allows staff to build on and support the work being undertaken in Inspiring Minds (either the Saturday programme or the Summer Schools)
    3. The formation of an Inspiring Minds alumni community that offers students virtual & campus opportunities e.g. support and mentoring in undertaking a silver CREST award; opportunities to take part in related outreach activities; chance to mentor or support on the Inspiring Minds: Junior programme

  These developments aim to reduce the disparity between students' experience of ISL and "school science" and in doing so increase their level of continued engagement in a way that support their engagement with STEM in HE. Additionally, we also know that HE participation barriers are not only about knowledge and access but also "soft" employability style skills. The alumni community would further the development of these skills for the students building their confidence, aspiration and HE application related skills whatever they choose to study.

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Appendix A

Examples of Inspiring Minds Student Curriculum Session Sheets

WHO AM I ONLINE?

ASKING BIG QUESTIONS THAT BRIDGE SCIENCE & OTHER DISCIPLINES

A portrait is an artwork created about a person or persons which tells us something about them. Is a selfie just another type of portrait? What impact does social media have on how we portray ourselves online - our digital portrait? What other information is being included with your selfie? This raises questions about the impact of technology on our identity and security of our "online selves".

WHAT'S IN A PORTRAIT?

The Ambassadors, Hans Holbein the Younger, 1533, Photo: wikiart

Artists have represented people in portraits for hundreds of years, and not just famous people. Portraits make us ask questions about who these people are, and why they have been captured in paintings and photographs for others to see and consider. Sometimes a portrait doesn't seem to look like the person it is meant to represent, but it may still show us something about that person.

FROM PORTRAIT TO COLLAGE

A collage takes already existing, unrelated materials and puts them together to create a new image. A collage can be made with newspaper clippings, fabric, coloured paper, parts of other artwork, photographs and objects, glued to a piece of paper or canvas. The pieces are arranged purposefully to create different effects on the audience - it might be emotional, or intended to make us think about how all the unrelated images work as a new whole.

Opened by Customs, Kurt Schwitters, 1937-8, Photo: © Tate, London 2018

SELFIES, COLLAGES AND SELF-PORTRAITS

Creating a self-portrait is an introspective process, but the self-portrait itself becomes a representation of ourselves out in the world, and it will be viewed in many different ways. By creating a self-portrait, we can learn more about who we are, and how we want to represent ourselves.
Can a collage be a self-portrait? Can a selfie be a self-portrait? Is it always necessary to present a true image of the person, or are emotions, interests, goals, and dreams just as important? Is the selfie the only way to present yourself on social media?

OVER TO YOU

First, the photo... Take two photographs of yourself with the instant camera. For the first try to be as natural as possible, for the second you'll show how you feel or view yourself. Wait until the end of the session to take your second photo! Then just have fun!

Then, the collage... Use a combination of your 'Insta' photo, the magazines, and a sheet of A5 or A4 paper to create a collage self-portrait.

Not sure where to start? Choose images based on how makes you feel; look for words in the text which are meaningful or represent your interests; pick out patterns within the images or use whole pictures featuring items which interest you. The choice is yours; there is no right or wrong way to do this.

WHO ARE YOU ONLINE REALLY?
Think about your experiences of using technology creatively

- How has this influenced the way you think about the portraits of you on digital platforms and circulating in social media environments?
- How much of yourself do you share online?
- Is the selfie the only way to present yourself on social media?
- Is "who you are" the same online as offline? What about across different platforms (social media/Role Playing Games etc).
- What would your online identity look like if there weren't any camera phones?

Want to know more? Turn over for careers & curriculum links

SESSION ACHIEVEMENTS:

- Engage with creative techniques to re-shape the way you represent yourself online.
- Exploring whether the self-portrait truly represents "image" in the modern digital age.
- Understand the difference between digital portrait and digital profile.
- Appreciate that scholars use many methods and some are more scientific than others.
- Art & Design – develop and refine ideas as you work and understand different graphic communication processes.
- English – Listen to and build on others' contributions, and ask questions to clarify and inform.
- Computing - Understand how changes in technology affect safety and ways to protect your online privacy and identity.

CAREERS TO THINK ABOUT

GAMES WRITER

The story is an integral part of video gameplay experience. Games writers work with the design team moving from concept through to final delivery. They are integral to everything from world design to character development and universe story. Game writers tend to have a love of both English and video games, and are imaginative thinkers who often study creative or script writing at university.

Susan O'Connor

Recognised as one of the most influential and original game writers in the industry working on project such as Far Cry 2, BioShock, and Gears of War. She is known for her innovative storytelling that pushes the boundaries of game content and bridges the line between video gaming and art.

EXHIBITION DESIGNER

Exhibition designers are creative thinkers with excellent design and communication skills. They may work on trade shows and public exhibitions for industry; or cultural exhibitions for museums, galleries and libraries. They are able to design their exhibition to reflect the needs of client and provide an engaging experience for customers and visitors.

Ioanna Gkritzani

Works at Natural History and Science Museums in London where she lets her "imagination go wild, transforming ideas, spaces and objects into installations that visitors can play with and learn from.

SOCIAL MEDIA DEVELOPER:

Social media developers are analytical thinkers who specialise in the technical management of an organisation's social media platforms. They design and create applications to engage their customers, and take their applications from idea to reality. Social Media Developers help to connect the world in ways that have never been done before.

Evan Spiegel

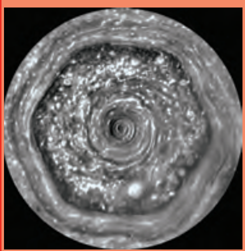
The founder of Snapchat. While studying at Stanford University, he proposed Snapchat as a class project for project design subject. His net worth is still around $4 billion, making him one of the youngest billionaires in the world.

WHAT'S THE UNIVERSE REALLY MADE OF?

ASKING BIG QUESTIONS THAT BRIDGE SCIENCE & OTHER DISCIPLINES

Maths is a language it has vocabulary, grammar and rules for sentences. If we can understand maths as a language it can help us to understand how the world works and how objects in it are connected. This raises questions about how we can make sense of very big and very small parts of our universe, and patterns that appear to arise from chaos.

FROM CIRCLES AND LINES



Source: NASA/JPL-Caltech/SSI/Hampton University

Although seemingly random, nature of full of patterns that follow mathematical rules. From how lightning forks to spiral of a snail shell and even the pattern of broccoli. In fact with just a circle and straight line you can recreate almost every shape in the universe

There is even a mysterious hexagonal cloud pattern at Saturn's North Pole. There are a variety of scientific descriptions of why the hexagon exists, but scientists need mathematics to show why it is a hexagon and not a circle, a star, or any other shape.

UNDERSTANDING NATURE'S BOOK

Maths gives us the tools to explain the fundamental behaviour of the universe from how molecules rotate and vibrate to whether a galaxy spirals clockwise or anti-clockwise. Algebra and equations work to explain complex ideas just like writing systems such as Japanese Kanji.

Kanji can express the difference between listening [聞く] and paying attention to what you're listening to [聴く] just like small variations in equations can explain and link very different concepts.

Source: wikicommons

A SENSE OF SCALE

Some patterns in nature, like the spiral of a pine cone are clear to us, but others are too big or too small to be seen. Just because we can't see the order it doesn't mean it's not there. But can mathematics really describe the behaviour of things from DNA to galaxies? If everything in the universe is describable by mathematics does that mean everything (including us) is following a strict path or can maths describe "chaos"? The short answer is yes, there's a whole branch of mathematics dedicated to chaos theory (also called the butterfly effect). **https://tinyurl.com/chaos-theory-IM**

OVER TO YOU

For your GCSE you will have to create a perpendicular line and bisect an angle - this uses similar techniques to go beyond your exam

Constructing a Hexagon - Use a compass to draw a circle on the page (not too small or this will get tricky!). DO NOT adjust the compass, place the point on the edge of your circle and draw a small arc where the pencil crosses the circle. Now put your compass on this point and repeat to get a third point. Keep going until you have six points on your circle. Connect adjacent points using a ruler to create a hexgon. **Can you build a honeycomb pattern?**

Building a Fibonacci Spiral - The fibonacci sequence starts at 0 or 1 and increses by adding the previous two numbers together: 0,1,1, 2, 3, 5, 8, 13, 21...This pattern forms a spiral also known as the golden ratio which is found across nature and architecture. Use squared paper to build a grid using the fibonacci sequence, theneither free hand or using the compass create a curve across each square until you have a spiral. **How big can you make the spiral? Can you build a double spiral?**

WHERE IS THE MATHEMATICS IN YOUR UNIVERSE?
Think about how you engage with maths without realising

- Find out just how big the minecraft world is or how small your chromosomes are at **scaleofuniverse.com**
- The maths behind CGI **www.mathscareers.org.uk/video/advancing-the-digital-arts/**
- Snowflakes, lightning patterns, the structure of shells and even broccoli are all examples of fractals in nature. **www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fibnat2.html**
- If maths exists throughout the universe did we create it, or discover it?

Want to know more? Turn over for careers & curriculum links

Part of the National Collaborative Outreach Programme

Canterbury Christ Church University

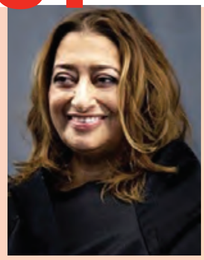
SESSION ACHIEVEMENTS:

- Understanding maths as a language.
- Understand some questions are more amenable to scientific explanation than others.
- Exploring how scale helps us to talk about the full range of size of objects in the universe.
- Appreciating the ordered pattern present in nature from the very small (e.g. DNA) to the very large (e.g. galaxies).
- Maths – Apply ratios to real contexts and model situations mathematically.
- Science – Develop an understanding of the methods of science and understand physical laws/models are expressed mathematically.

CAREERS TO THINK ABOUT

ARCHITECT

Architects have been using mathematical proportions to design buildings form the great pyramids in Egypt to the Gherkin in London Architects are problem solvers who can think and design creatively and then communicate those ideas to a client. They have often studied Art & Design and Maths at school.



Zaha Hadid

Zaha Hadid was a multi award winning Iraqi-British architect, known as "Queen of the Curve". Her buildings can be found from Beijing to Glasgow and she designed the London Aquatics centre for the 2012 Olympics. She was made a Dame for her service to architecture.

BIOPHYSICIST

Biophysicists explore issues where biology and physics meet, which means they're creative thinkers who want to know about relationship between physics and living organisms. They are at the forefront of major advancements in science and medicine, particularly with DNA. They can work for the government, in many industries or doing research in a university.

Candice Etson

Candice Etson trained as a ballet dancer gaining a degree in Fine Arts and Dance. After a few years she returned to university to study physics and gained her PhD at Harvard. She currently looks at how your DNA turns one cell into a muscle cell and another in to a skin cell at the level of individual molecule.

ANIMATION SCIENTIST

CGI animations in films, computer games and scientific modelling are all built using models that are realistic, but can also be processed quickly enough by a computer. Animation scientists work in teams to create accurate models that help us tell better stories.

Tony DeRose

Tony DeRose is an animation scientist at PIXAR. With a degree in physics and a PhD in computer science, he translates arithmetic, geometry and algebra into clouds, smoke and bouncing hair.

DOES SIRI "JUST" LISTEN?

ASKING BIG QUESTIONS THAT BRIDGE SCIENCE & OTHER DISCIPLINES

The EU (European union) are debating how we regulate artificial intelligence (AI) including "electronic personhood". This raises the question how should we understand the advance of human-like robots – should it make us appreciate how very special we are and so, what a long way robots have to go? Or should it make us realise that we're not very special and everything we think is special, will one day be explained by science?

CAN YOU TELL A ROBOT FROM A HUMAN?

Source: pixabay

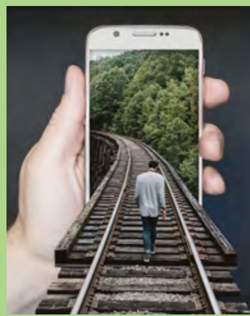
Alan Turing designed a method to test whether a machine can fool us into thinking it is human. In order to pass a machine must convince someone (who can't see it) they are talking to a person. In the test humans don't know if they are interacting with a robot or a person. Sometimes the humans on the other end "fail" the Turing test – people think that they are talking to a robot!

Understanding what, if anything, makes us different from machines can help us realise our criteria for saying another entity is a "person".

TECHNOLOGY AND LANGUAGE

We talk about "smart" phones, machine "learning", and Siri & Alexa "listening" to us. But what do we actually mean when we use these words? Is your phone smarter than you?

Can it provide information a place you've never heard of more quickly than you? Yes. Can it appreciate that a sunset can be beautiful? Did you answer differently? A similar comparison applies when we talk about the robot "hearing" us or simply responding to sound. Does the robot understand the command?



Source: pixabay

WHEN IS AI ABOUT MORE THAN PROGRAMMING?

We live in an increasingly technological world where everything from our sleep patterns to our regular commute can be recorded through technology. As technology becomes increasingly more integrated into our lives and habits the boundary between technology and other disciplines becomes increasingly blurred. Can (or should) the programmer be able to answer whether we should use androids in healthcare? Who is responsible when a robot reacts differently in the real world to the lab? Should a robot be granted citizenship and if so when? Can art created by technology have the same value as a work by a famous artist?

To be able to answer these questions (and many others) raised by the use of AI, robotics and technology we must seek to integrate the knowledge and thinking provided by a range of disciplines and understand the power and limitations of each to provide part of the answer.

OVER TO YOU

This is an opportunity to explore how we judge whether something is "human-like" and think about the language we use about technology.

Artificial "intelligence"? -Spend some time talking to Mitsuku - what questions is "she" able to answer easily? Where does "she" struggle to give a human response? https://tinyurl.com/IM-mitsuku
Loebner Prize - Have a conversation with "Millie" about the Turing Test - can you work out whether you are speaking to a robot or human? what happens when you ask about topics other than the Turing test? https://tinyurl.com/IM-turing

ROBOT OR "ELECTRONIC PERSON"?
Think about how you would make the distinction

- What's the difference between hearing, listening (which Siri & Alexa do a lot of apparently), and responding to sound?
- What are the real sticking points that cause challenges for designing robots that interact or "think" like humans?
- If we wait, will technology one day become so complex that consciousness appears? Will there be a "consciousness" chip that engineers can add if it's useful? Or is consciousness nothing like either of these?

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SESSION ACHIEVEMENTS:

- Critically examine the language we use to describe technology and the complexity of the AI debate.
- Understand that some questions are more metaphysically sensitive than others.
- RE & Citizenship – understand the role of justice in society and the place of moral responsibility.
- Science – understand the power and limitations of science at dealing with ethical issues.
- Computing - apply analytic, problem-solving, design, and computational thinking skills.

CAREERS TO THINK ABOUT

LAWYER

A lawyer provides legal protection for people, and does far more than keeping people out of gaol. Lawyers offer representation (in court) and legal advice to individuals and whole companies. Dealing with court proceedings or small disputes they are often interested in history and English. You can specialise in a whole variety of areas from property or family to the environment there will be something for you.

Cherie Blair

Known professionally as Cherie Booth QC, she is an English barrister. She is married to Tony Blair, the former British Prime Minister. She specialises in employment, discrimination and public law and has represented claimants taking cases against the UK government.

ROBOTICS ENGINEER

A robotics engineer is a creative problem solver, who design solutions to the world's problems. They create new applications for robots and continually find new ways to expand their uses. They work in any industry that can benefit from the technology they create. Engineers typically develop designs, create prototypes and experimental robots, and work on applications that can range from military to medical use.

Melonee Wise

The CEO (Chief Executive Officer) of Unbounded robotics. The company design robots like UBR-1 that can do household tasks such as bringing you drinks, and laying the table. The company is be the one making the first semi-humanoid multipurpose robots that people actually have at home.

MARKET RESEARCHER

Market researchers interview people to find out what they think about products, services or issues. Market research executives and managers usually work for consultancies or in-house marketing/research departments - this can be in practically any industry. The data you collect will normally revolve around what organisations or people buy, need, do or think and the reasons why.

Michelle Goddard

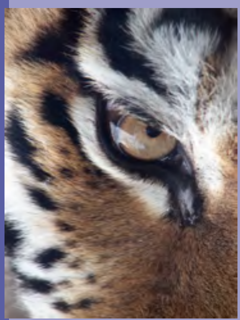
A graduate of the London School of Economics and Political Science, she received her Ph.D. in Law from Osgoode Hall Law School, York University, Canada in 2011 and has a wealth of experience in consumer market regulation and research.

IS SEEING THE SAME AS BELIEVING?

ASKING BIG QUESTIONS THAT BRIDGE SCIENCE & OTHER DISCIPLINES

Science requires observable, objective data. We think reporting on what we see/measure is more accurate and repeatable than reporting on our feelings. But psychologists and neuroscientists point out our senses don't exactly reproduce the reality of the world around us. This raises questions about the difference between our perceptions and 'reality' including how we interpret the physical world.

PERCEPTION



Source: Wikicommons

Some optical illusions occur because of the structure of the eye.Imagine how your view of the world would be different if you had the same eye structure as a dog (the worls is in shades of yellow, blue and grey)… a bee (very poor at detail, but very sensitive to motion)… a rabbit (you can see nearly 360° around you and far above your head, but you have no depth perception for objects close to you).
Find out more: tinyurl.com/IM-animalsight

ASSUMPTION

The brain is a very powerful tool, but to process all the visual information we receive our brain would need to be bigger than a building, and then it still wouldn't be enough. In order to process all this information we (subconsciously) simplify the information we are processing in order to reach decisions at greater speed. It is thought these cognitive "shortcuts" or biases allow us to make decisions quickly, helping our ancestors survive dangerous or threatening situations.

The world you think you are seeing has been constructed in your mind based on your mental model of what's out there! Optical illusions help us study how our mind reates a mental model of reality.

SCIENTIFIC METHOD

Although we often talk of a logical path of "scientific method" scientific discovery is more like a detective story. New discoveries are made with hundreds of people working alone or in groups to share information. Sometimes discoveries happen through mistakes, luck, mathematical appeal or guesswork. A big part of scientific research is thinking creatively about problems, asking new questions that people haven't thought of and finding a way to answer them. It's about stepping outside the comfort zone of existing knowledge and trying something new.

OVER TO YOU

The Stroop Test… In pairs time each other on how long it takes to say the COLOUR of each word in two lists. Use your phone/a stopwatch to record and compare the time taken for each list. If the person does not say the correct colour they will have to repeat the word. What do you think it shows? Is the test useful?

Newton's Colour Wheel…Use a compass to draw a circle about the sixe of a DVD on the white card. Mark the centre point, and draw three lines through the centre so the circle is divided into six spaces. Colour or use coloured card to make the sections red, blue, gree, red, blue, green.
Put a pencil through the centre of the disc and use it to spin the disc as fast as possible. what do you notice about the colours? You are trying to spin the disc faster then your eyes can process the colours

CAN YOU TRUST WHAT YOU'RE SEEING?
Think about the issues of how our sensory data is interpreted

- If you were born and lived on Mars are there any optical illusions that we have on Earth that wouldn't work for you?
- What is the dividing line between perception of reality and hallucination – is it a clear line?
- Which is more important for a scientist – imagination, systematic thinking, or both?

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SESSION ACHIEVEMENTS:

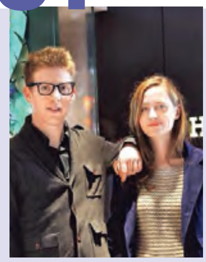
- Be able to relate the idea of cognitive bias to an explanation of why optical illusions work.
- Develop an understanding of the complexity of science in relation to the "scientific method".
- Challenge the claim that we can draw objectively on sensory data.
- Understand the power and limitations of science in dealing with observed data.
- Science – use scientific theories and explanations to develop hypotheses.
- Psychology – explain what causes optical illusions and the role of visual cues in perception.

CAREERS TO THINK ABOUT

VISUAL MERCHANDISER / DISPLAY DESIGNER

Display designers and visual merchandisers use their design skills and creativity to help promote an organisation's image, products and services. Display designers usually focus on displays for exhibitions and events. Visual merchandisers focus on window and in-store displays. People that enter these careers have excellent communication skills and an ability to turn an idea into reality.

Lucie Thomas and Thibault Zimmermann



(Known as Zim&Zou) are French artists who have made displays for companies like Hermes, IBM and Microsoft. They focus on handcrafted objects in a strict move away from computer design.

NEUROSCIENTIST

Neuroscientists study the development and function of the nervous system, which includes the brain, spinal cord, and nerve cells throughout the body. They could specialize in one part of the nervous system, or focus on specific behaviours. You might work directly with patients in hospitals and/or do research in a laboratory or office.

David Eagleman

Directs the laboratory for Perception and Action at Baylor College of Medicine and the Initiative on Neuroscience and Law. He is also a New York Times bestselling author.

PHOTOJOURNALIST

Photojournalists are experts at communication with a deep understanding of how the public will perceive the story through their images. Photojournalist's will take images that are difficult to capture, and convey intense emotion. These will be used in magazines, websites and even books.

Lee Miller

© Telrunya/ WikiCommons

Started as a model for vogue before moving in to photojournalism when she became their official war photographer for World War II. She documented the Blitz of London, the first use of Napalm, the Liberation of Paris and the Nazi concentration camps at Buchenwald and Dachau.

Appendix B

Summary of results from statistical analysis for change in attitudes to STEM scores (matched pairs)

Variable	Statements	Statistical significant (Wilcoxon)	Statistical significant (t-test)	Effect size (d)[1]
Educational aspirations (n=146)	I am motivated to do well in my studies	0.213	0.144	0.09
	I am confident I could get the grades I need for further study	0.046	0.057	0.12
	I am confident I could gain a place on a course of my choice if I wanted to	0.001	0.001	0.27
Self-concept in STEM (n=112)	I find STEM subjects difficult (reverse coded)	0.202	0.217	0.09
	I am just not good at STEM subjects (reverse coded)	0.451	0.534	0.04
	I get good marks in STEM subjects	0.775	0.720	0.02
	I learn STEM subjects quickly	0.097	0.162	0.10
Future Participation in STEM (n=112)	I would like to study more STEM subjects in the future	0.007	0.008	0.19
	I would like to study STEM at university	0.001	0.001	0.28
	I would like to have a STEM related job	0.001	0.001	0.25
Importance of STEM in society (n=112)	STEM is important for society	0.001	0.002	0.22
	STEM make our lives easier and more comfortable	0.001	0.001	0.36
	The benefits of science and technology are greater than the harmful effects	0.001	0.001	0.33
	There are many exciting things happening in science and technology	0.001	0.001	0.28
Future Intentions (n=146)	How likely are you to apply to higher education in the future?	0.027	0.052	0.12
Perceptions of HE (n=146)	It is for people like me	0.001	0.001	0.35
	I would fit in well with others	0.001	0.001	0.32
	I have the academic ability to succeed	0.002	0.002	0.19
	I could cope with the level of study required	0.012	0.014	0.15
Self-efficacy (n=112)	If I study hard I will get better marks	0.183	0.181	0.10
	I feel that I have a number of good qualities	0.007	0.007	0.20
	I am able to do things as well as most other people	0.004	0.005	0.20
	Setbacks do not discourage me	0.006	0.005	0.21
	I am a hard worker	0.154	0.127	0.11
	I finish whatever I begin	0.016	0.021	0.17
	I feel good about myself	0.013	0.017	0.17
	I am responsible for what happens to me	0.410	0.409	0.06

[1]Effect size calculated using d=t/sqrt(N). Where N = total observations, pre and post surveys. Cohen's d: 0.2 to 0.5 = small effect, 0.5 to 0.8 = medium effect, 0.8 and higher = large effect.

Appendix C

Indicative Interview Schedules

STUDENT SEMI-STRUCTURED INTERVIEW SCHEDULE

Part 1 – Inspiring Minds Project

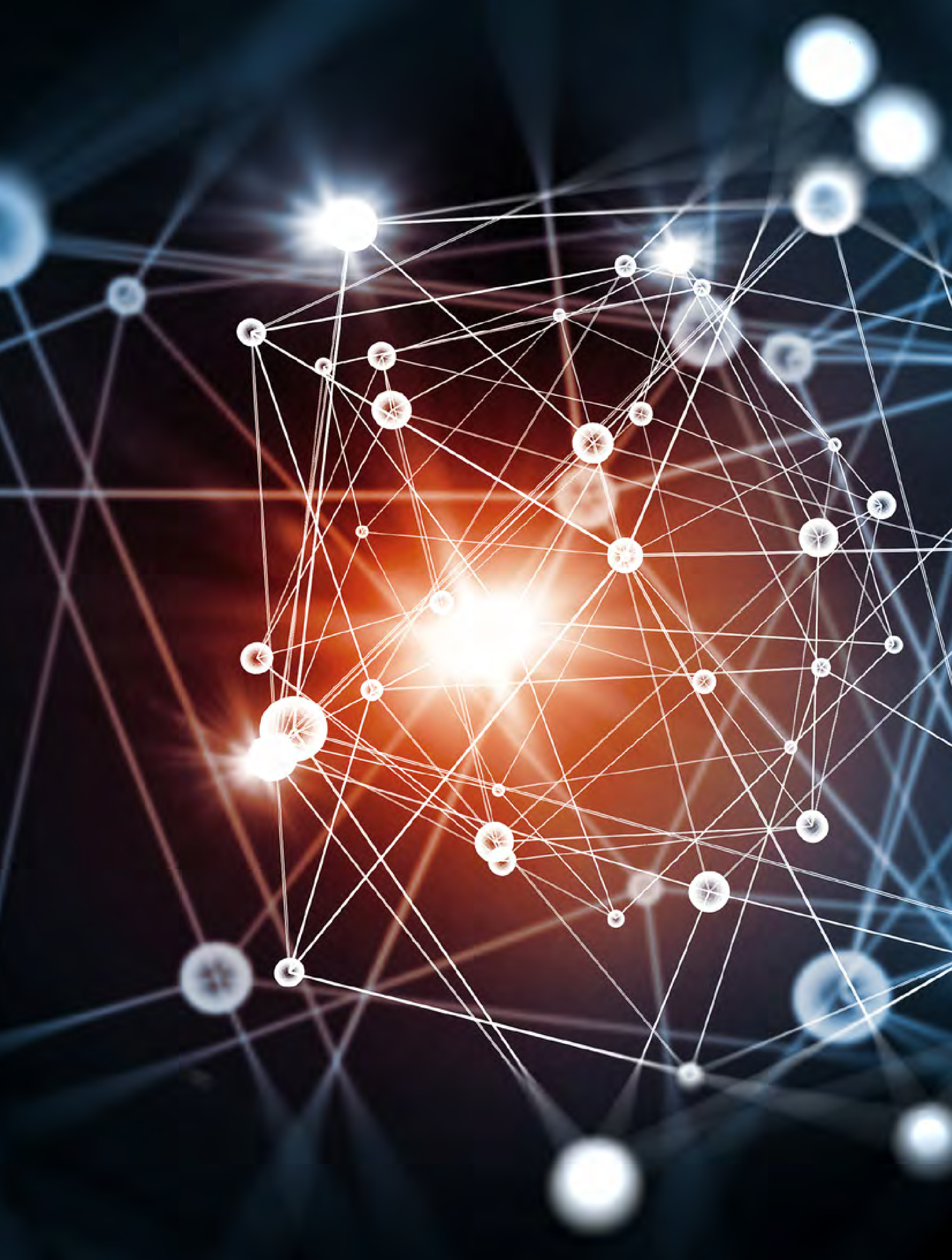
1. Have you had opportunities to be involved in other extra-curricular activities organised by school?
2. What was your initial motivation for joining the Inspiring minds project?
3. **possible pick up of student comments from Q1 on Questionnaire*
4. How much did you know about the topics you've explored before you started?
5. **possible pick up of student comments from Q3/Q4 on Questionnaire*
6. What was the most challenging aspect of the course?
7. Each Saturday was broken down in to three sessions: a workshop, CREST Award Session, and the Mind and Body session – what was your experience of these sessions?
8. How could the project be improved in future?

Part 2 – Wider Impact

1. Would you say that the project has impacted on your experience in science lessons at school?
2. Has it impacted on your experience in other lessons, for example in class discussions?
3. Has the career information or the project experience influenced whether you would consider a science-related career?… **possible pick up of students comments from Q5 on Questionnaire*
4. Finally, the project asked you to take part in learning outside school … **pick up on student comments from Q2 on Questionnaire*

SEMI-STRUCTURED INTERVIEW SCHEDULE FOR TEACHING STAFF

1) How did you hear about the Inspiring Minds Project?
2) Have you been involved in other outreach events by CCCU?
    a. If yes what?
    b. If No why not?
3) What drew you to taking part in the Inspiring Minds Project?
4) What were you hoping your students would gain from the project?
5) What were you hoping you would gain as a school from taking part in the project?
6) Have you or other staff noticed an impact on participating students' attitudes in school …
    a. In science subjects?
    b. More broadly?
7) Have you or other staff noticed an impact on participating students' attainment …
    a. In science subjects?
    b. More broadly?
8) In your view, what worked well and do you have any feedback to help us improve for another time?
9) What – if any - other wider benefits have you noticed by participating in the project?



www.canterbury.ac.uk/inspiringminds