The impact of human spaceflight on young people's attitudes to STEM subjects

Interim report to the UK Space Agency and ESRC
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Executive summary

1. This report covers the baseline data collected for the RISES (Research into Spaceflight and Engagement with STEM) project, which explores the impact of human spaceflight on young people's responses to STEM subjects. The project is linked to the *Principia* mission in which the astronaut Tim Peake visits the International Space Station.

Methods

2. The project adopts a mixed methods approach, gathering quantitative data through the use of an attitude survey with students, and qualitative data through interviews with key informants, students and teachers. Additional quantitative data from the National Pupil Database (NPD) allow for the characterisation of schools participating in the project.

3. Data collection is taking place at three points: baseline data prior to Tim Peake's mission to the International Space Station in November 2015, immediate follow-up data during the mission (first part of 2016), and longer-term follow-up data approximately one year later (mid-2017).

4. The participating groups of students are upper primary age students (age 8-11) and lower secondary age students (age 11-14), aged 8 and 11 at the start of the project.

5. A map of resources linked to the *Principia* Mission is being developed as part of the project.

Progress to date

6. A dedicated on-line survey to assess students' affective responses to STEM subjects has been developed for the project. The survey includes a section on space science.

7. Ten key informants have been interviewed.

8. Baseline survey data have been collected from 23 primary schools and 18 secondary schools, with a sample size of 797 primary age students and 1600 secondary age students.

9. Interviews have been conducted at 17 case study schools, nine primary schools and eight secondary schools.

10. The key informant interviews have been analysed.

11. The fixed-response items in the on-line survey have been analysed.

12. Further analysis is required for the open-response items on the on-line survey, and for the interviews with teachers and students in the case study schools.

13. A database of resources is being compiled as an on-going aspect of the project

Findings

14. Most key informants are positive about the potential of the *Principia* mission and Tim Peake's work to improve young people's attitudes to STEM subjects and to space. Space was seen as a very useful context in which knowledge and understanding of STEM subjects could be developed, and also a good means of promoting awareness of a range of careers in STEM. There were aspirations for space science to serve as a way of attracting young people from traditionally under-represented backgrounds into STEM careers more generally.

15. Overall, both primary and secondary students are positive about the value of STEM subjects, and about space. They believe science makes an important contribution to people's lives, and technology and engineering can also help improve things. Their views of the contribution of mathematics are less positive.

16. Students' confidence about their abilities in science and maths is about the same in the primary and secondary age ranges. They are less confident about their abilities in engineering, which was explored in the secondary school survey only. This may well be explained by their lack of confidence about what the subject entails, as there have no dedicated engineering lessons.

17. More secondary students than primary students believe they will need to use science, technology and, especially, maths in their jobs.

18. There is a downward trend from primary to secondary age groups in relation to considering careers in STEM subjects, particularly for maths, with around half of secondary school students seeming already not considering careers involving those subjects. Views of careers involving technology are more positive.

19. Space science is viewed very positively and seen as making a worthwhile contribution to people's lives, with the majority of both primary and secondary age students believing that space science makes lives on Earth better. There was also support for sending people into space to find out more about the universe, and that this activity was worth the money spent on it.

20. Whilst the National Curriculum for England does not have a requirement for teaching about space, some teachers bring space-related activity into their lessons. Students in some schools were already aware of Tim Peake and his mission at the time of the baseline survey. Students were able to report on a range of space-related matters they had learned about in the last year.

21. There is a belief that you need to be clever to do a job in space science or technology, even more so than the need to be clever to do maths and science.

22. Space is a topic of significant interest to students, both in school and outside school. The positive responses are particularly pronounced in the primary age group.

23. Primary students believe more strongly than secondary students that they have the ability to attain a job in space science.

24. Students are very positive about the possibility of them travelling to space, though less interested in careers involving space science. Boys are particular positive about travelling to space, with the divide between boys and girls more pronounced in the secondary age group.

25. Some confusion about STEM-related clubs in schools emerged, particularly in secondary schools, and linked to the use of the word 'club' for remedial or additional support classes. Where STEM-related clubs did exist in the form of an 'extra' for interested students, they covered a variety of topics including environmental matters, health matters, additional practical activities to those undertaken in lessons, computer programing and space/astronomy clubs.

26. Primary age students are much more positive about participation their schools' STEM-related clubs, with enthusiasm being highest for space/astronomy clubs.

Section 1: Background

Spaceflight has a fascination for many people, and there is evidence, much of it anecdotal, to suggest that space and space travel increase the interest of young people in science, technology, engineering and mathematics (STEM) subjects. This suggestion comes from groups including people who work in space science and related areas, those involved in developing formal and informal activities related to learning about space science and spaceflight, and classroom teachers. Much of the published work comes from the United States (e.g. Fraknoi, 2007). However, little systematic empirical evidence has been collected to assess the strength of claims made about interest in space travel and uptake of STEM subjects. Tim Peake's mission to the International Space Station in December 2015 provides an ideal opportunity to test the hypothesis that spaceflight and space travel have a positive impact on young people's perception and uptake of STEM subjects.

Section 2: Objectives of the project

Note: To give the project an identity, and for ease of communication, the project has been called the *RISES* project (Research Into Spaceflight and Engagement with STEM), and this name will be used throughout the report.

The RISES project has five principal objectives:

- to design an online survey to gather information on young people's attitudes to STEM subjects, including attitudes to human spaceflight;
- to use the survey to gather longitudinal data over a three-year period to track the attitudes to STEM subjects of two cohorts of young people, one cohort in primary schools and one in secondary schools;
- to undertake interviews with teachers and students in case study schools in order to explore in more detail factors that may influence attitudes to STEM subjects and to human spaceflight
- to gather information from a range of key informants on their aspirations for the impact of Tim Peake's mission to the International Space Station;
- to produce a map of major resources that are developed and linked to Tim Peake's mission.

Section 3: Overview of the project

3.1 Overall project design

The project adopts a mixed methods approach, gathering quantitative data through the use of an attitude survey with students, and qualitative data through interviews with key informants, students and teachers. The quantitative data yield a broad picture of responses that describe the situation in relation to perception and possible uptake of STEM subjects, whilst the qualitative data enable responses to be probed in more detail to identify possible explanatory effects. Additional quantitative data from the National Pupil Database (NPD) allow for the characterisation of schools participating in the project.

The target groups of students are those aged 7-11 (Key Stage 2) and 11-14 (Key Stage 3). The three-year duration of the project makes aspects of a longitudinal study possible, i.e. data can be gathered at three points: baseline data prior to Tim Peake's mission to the International Space Station in November 2015, immediate follow-up data in the period following the mission (first part of 2016), and longer-term follow-up data approximately one year after this (2017). The project is collecting data from two cohorts of students, aged 8 and aged 11 at the start of the project.

3.2 Details of the project

The project runs from 1 February 2015 to 31 January 2018, and has five main phases, as summarised below.

Phase	*Approximate timescale*	*Key activities*
Phase 1: Establishing the context and identification of the sample	January 2015 - June 2015	• Obtaining ethical approval for the project • Interviews with key informants • Identification of sample of participating schools, teachers and students through use of National Pupil Database (NPD)
Phase 2: Development of research instruments and data collection 1 (baseline data)	January 2015 - June 2015	• Development and validation of research instruments (student attitude survey, interview schedules for key informants, teachers, students)
	June 2015 - December 2015	• Data collection 1 (baseline data) from schools, teachers and students
	December 2015	• **Tim Peake flies to International Space Station**
	December 2015	• Collection of data on major forthcoming space science resources
	January 2016 - May 2016	• Analysis of baseline data
Phase 3: Data collection 2 (immediate follow-up data)	March 2016 - July 2016	• Data collection 2 (immediate follow-up) from schools, teachers and students
	July 2016 – December 2016	• Analysis of immediate follow-up data
	December 2016	• Update data on space science resources
Phase 4: Data collection 3 (longer term follow-up data)	January 2017 - April 2017	• Main data collection 2 (longer term follow-up data) from schools, teachers and students
	May 2017 - August 2017	• Follow-up interviews with key informants
	May 2017 - October 2017	• Analysis of longer-term data
	September 2017 – December 2017	• Production of map of resources
Phase 5: Production and dissemination of project outputs	January 2018	• Production of end-of-project report and other project outputs as agreed with the UK Space Agency and ESRC

Ethical approval for the project

Ethnical approval for the project was obtained through the appropriate procedures of the researcher's institute. The project conforms to the British Educational Research Association (BERA) Ethical Guidelines for Educational Research (BERA, 2011).

Interviews with key informants

The key informants are people who have specialist knowledge of space science through their everyday roles and activities. They include directors and managers of agencies with a remit to promote space science activities, university-based physicists working in space science, school-based physics/science teachers, and providers of outreach activities (e.g. The National Space Centre).

The key informant interview schedule may be found in Appendix 1.

The purpose of the interviews with key informants is to gain their perspectives on key areas in space science that may influence students' responses to STEM subjects. Key informants are also asked to identify any key space science resources and activities that are currently used in schools and, where appropriate, comment on their perceptions of impact. Key informants have been interviewed in the first phase of the project, and will be interviewed again towards the end of the project.

Development of the on-line survey to gather data on young people's attitudes to STEM subjects

A dedicated on-line survey has been developed for the project, as there are very few examples of existing single instruments to assess students' affective responses to STEM subjects. In constructing the survey, recognition was made of the fact that the term 'STEM' is unfamiliar to the majority of school students, who are more likely to talk in terms of the curriculum subjects they study, such as science (or individual sciences), maths and technology.

The survey was developed with reference to a range of existing instruments. These included: for science, the ASPIRES project (Archer et al., 2013), the ROSE (Relevance of Science Education) project (Sjøberg and Schreiner, 2010), the Attitudes to science and school science project (Bennett and Hogarth, 2009), the VOSTS (Views on Science, Technology and Society) project (Aikenhead and Ryan, 1992); for mathematics, the UPMAP (Understanding Participation rates in post-16 Mathematics And Physics) project (Mujtaba and Reiss, 2013), Brown et al., 2008) and ATMI (Attitudes Towards Mathematics Inventory) in its short version (Lim and Chapman, 2013); for technology, Ardies et al. (in press) and PATT, Pupils' Attitudes Toward Technology (Bame et al., 1993); S-STEM (Students Attitudes Towards STEM surveys (Friday Institute for Educational Innovation, 2012 and 2012b). Additionally, instruments used in the Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMSS) and the Wellcome Monitor were consulted.

Existing instruments were analysed systematically for similarities in style and focus. For example, many attitudinal instruments gather data through the use of Likert (agree/disagree) scales and cover levels of interest in subjects, career aspirations, responses to STEM disciplines within and beyond school, and gender aspects. A specific search was also done for items that probed responses to aspects of space science and the social usefulness of space science.

Based on the above analysis, a new instrument was developed. Care was taken to probe similar aspects for each of the STEM subjects, for example, views of [STEM subject] in school, views of [STEM subject] outside school lessons, careers involving [STEM subject], external influences from family/peers/teachers, confidence and/or perception of difficulty of [STEM subject]. A specific strand on spaceflight was included, expanding on items from existing instruments.

Separate surveys were developed for the primary and secondary age ranges to take account of aspects such as curriculum experiences and levels of maturity. However, the areas probed were kept as similar as was feasible. The two major differences in the surveys were the use of a three-point Likert scale for primary age students, rather than the five-point scale used with secondary students, and the combining of the sections on Technology and Engineering into one section related to

‘Designing and making’. This later approach was adopted following consultation with primary school teachers about the curriculum in their schools.

Copies of the surveys for primary level and secondary level students may be found in Appendices 2 and 3.

Identification of the sample and recruitment of schools

Schools were identified in a number of ways. Staff on the research team and staff at ESERO sent out emails on behalf of the project, and schools applying to take part in certain *Principia*-related projects were similarly invited to join the project. Project team members also approached personal contacts. In addition, the project was publicised through a range of email lists, and this resulted in people in a number of schools contacting the project staff directly.

The National Pupil Database was used to identify a range of school characteristics, including school achievement in science, levels of STEM subject uptake, gender and ethnicity of students, socio-economic status of students’ families/carers, and measures of disadvantage/deprivation.

It was recognised that care needed to be taken to ensure the sample did not reflect a preponderance of schools already heavily engaged in, or committed to, activities related to Time Peake’s mission. Data from the NPD enabled the recruitment process to be expanded to include schools which had not been in contact with any of the science education or space-related projects. Schools were selected for approach by creating randomly generated batches from the full NPD list acquired.

Case study schools were identified based on patterns of responses to the survey, and care was taken to reflect a broad range of schools and likely interest in space science in the case study group of schools.

Data collection from schools

Baseline data have been gathered via the on-line survey and through interviews at case study schools. This will be followed up with two further phases of data collection, one during Tim Peake’s mission, and one approximately a year later.

The interviews with students focus on probing in more detail responses from the survey, gathering data on views of STEM subjects, their current thoughts on post-compulsory study of STEM subjects, their experiences of space science within and outside school, and their knowledge of the proposed visit of Tim Peake to the International Space Station.

The teacher interviews gather perspectives on key aspects that influence their students’ responses to STEM subjects. Teachers were asked about the effects of space science activities in particular, and what their school does (or may be planning) in relation to space science, and what impact they think this will have on students’ responses to STEM subjects.

Copies of the baseline data interview schedules for teachers and students may be found in Appendices 4 and 5.

Follow-up data collection

Two further phases of data collection in schools are planned, one in the first part of 2016, and the other in 2017. This will provide immediate follow-up data, and longer-term follow-up data.

Participating students will complete the attitude survey for a second time, and follow-up interviews will focus on students' responses to STEM subjects generally, and also in the light Tim Peake's mission. The interviews will seek to establish in what ways responses have changed (if they have), and the reasons for any change. Teacher interviews will seek to establish what their students have actually experienced in relation to activities about space science, and Tim Peake's mission in particular.

The map of resources

The map will consist of existing major space science resources and activities already in use in schools to promote awareness of space science, or resources being developed as a result of Tim Peake's mission. Whilst this will include resources students may encounter as part of their formal curriculum, the focus will be on enrichment resources and activities to supplement the curriculum. In addition to the research team's knowledge of the area, resources will also be identified through discussion with key informants, and through scrutiny of resources such as those made available through, for example, the National STEM Centre, the UK-ESERO (the European Space Education Resource Office), and the Institute of Physics.

A database of resources is being compiled as an ongoing aspect of the project, and will be finalised in December 2017.

Planned project outputs

The planned outputs for the project are likely to include:

- detailed interim and final project reports, as agreed with the UK Space Agency and ESRC
- a summary report for staff in schools, including head teachers, teachers and governors, and staff in universities and other locations who provide widening participation activities focusing on aspects of space science
- a validated survey instrument for collecting data on students' attitude, uptake and engagement in STEM subjects, with a separate strand on space science and the societal usefulness of space
- a map of activities used developed to stimulate students' interest in space science
- academic research publications

Section 4: Progress to date

4.1 Development and piloting of the on-line survey

The survey has been developed and piloted with 81 primary and 158 secondary school students from five primary and four secondary schools. Following the pilot, minor modifications were made, and the survey finalised.

The survey was created with Google Forms. A link to the online survey was sent to the teacher organising the data collection in each school in the form of a short URL, which could then be accessed by each participant. Participants submitted their own responses once complete, which were then automatically stored.

4.2 Recruitment of schools

32 primary and 27 secondary schools were recruited to complete the on-line survey by the deadline of 15 December 15 2015, the date on which Tim Peake would travelled to the ISS.

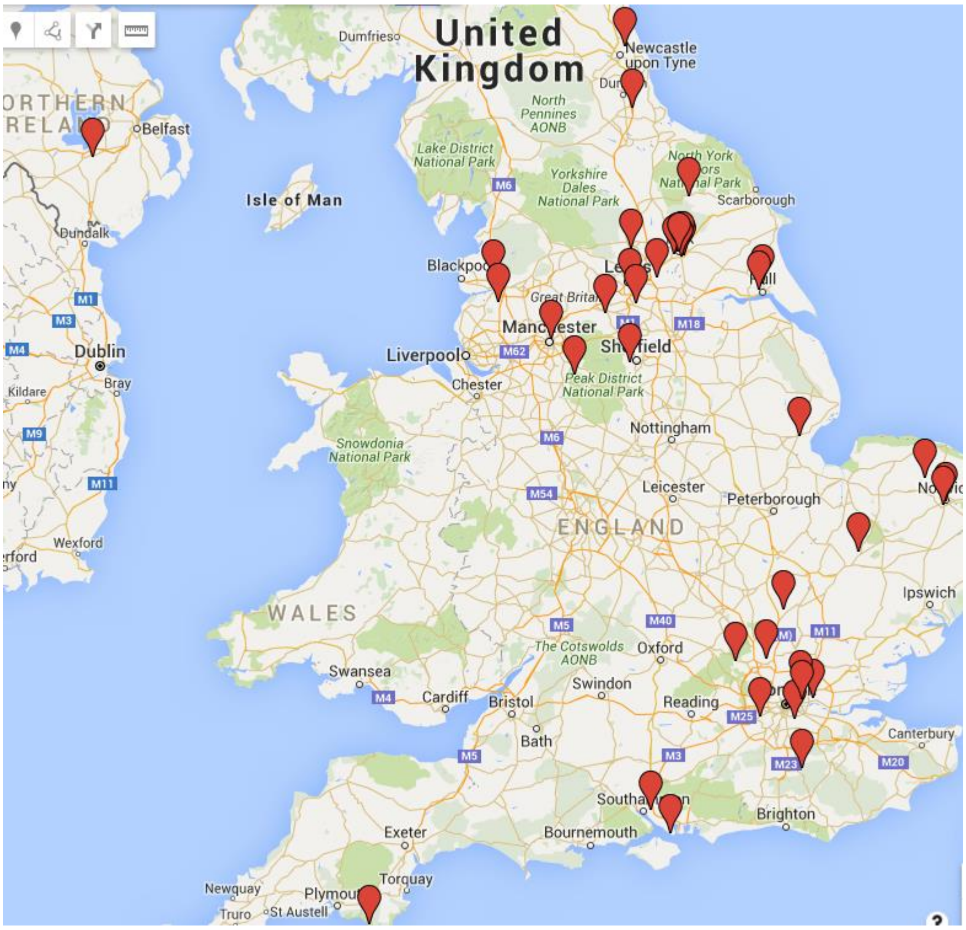
In practice not all the schools recruited participated in the survey, and a small number returned data after 15 December 2015. Thus the final sample consisted of 23 primary schools and 18 secondary schools, giving a sample size of 797 primary age students and 1600 secondary age students.

Three secondary schools requested paper copies of the survey. Thus the secondary student sample consisted of 1184 electronic responses, and 416 paper responses.

17 case study schools were identified: nine primary schools and eight secondary schools.

Figure 1 shows the location of the 41 schools participating in the schools.

Figure 1: Location of schools participating in the project



4.3 Analysis of survey data

The fixed response items in the survey were coded into numerical form, with the most positive answer acquiring the highest number. For example, the Likert items on the survey used with secondary students coded 'strongly agree' as 5, through to 'strongly disagree' as 1. Similarly, items such as whether or not the school had any STEM clubs were coded 'yes' = 3, 'I don't know' = 2 and 'no' = 1.

For the analysis of the baseline data, the 'strongly agree' and 'agree' responses for secondary students were combined into one group to enable comparisons to be made with data from primary schools, where only the 'agree' option was used. 'Disagree and 'strongly disagree' responses were similarly treated.

4.4 Analysis of interview data

The interview recordings with key informants, teachers and students were transcribed, and transcripts given to adult interviewees for verification and accuracy checks.

4.5 The map of resources

An electronic log has been established to keep records of media and electronic resources, and facilitate the production of the map of resources. At the point of writing this report (February 2016) the log contains records of approximately 250 items.

Section 5: Interviews with key informants

This section reports on the information gathered through qualitative, semi-structured interviews with ten key informants. The key informants included space scientists, teachers and others with a strategic role in relation to space science and formal and informal STEM Education, including some with direct involvement in the *Principia* mission. Interviews lasted between 20 and 60 minutes and were carried out by one of three researchers (Airey, Dunlop and Turkenburg). Key informants were asked about their organization and their role within it, their aspirations for the *Principia* mission and its potential for influencing young people's attitudes towards STEM subjects. Each interview was audio-recorded, transcribed and the transcript returned to interviewees for verification if requested. The transcripts were analysed to generate respondents' views on human spaceflight, and in particular the *Principia* mission and how this relates to young people's responses to STEM subjects.

5.1 Knowledge about the *Principia* mission

Key informants identified a range of general aims for the *Principia* mission, including scientific, technical, geopolitical and economic aims, as well as those related to the future UK space science workforce. However few key informants (indeed only those with direct involvement with *Principia*) were aware of the specific scientific and educational aims of the mission.

Some key informants noted the interconnectedness between the different aims. For example, one interviewee observed:

> *… research and development and technology and exploration in space is funded…is very much related to how the government can see the outcome, and those outcomes are not tied to science papers or the things I might find important, but they are actually tied to 'have we engaged more people in the process? Have we engaged more industry in the process and have we generated money and growth or better training?'*
>
> Key informant F, scientist

5.2 Perspectives on the *Principia* mission

The *Principia* mission is distinct from other recent space missions in that it involves Tim Peake as the first British ESA astronaut to visit the ISS. Several key informants suggested that Tim is perceived to be engaging, inspiring and a good communicator. For several key informants, this was an important factor likely to impact on the inspiration of young people in part due to increased UK media coverage of British space activity surrounding the launch.

Several interviewees anticipated that young people would be able to relate to the British astronaut and believed that having a British astronaut in space would resonate with the public in ways that robotic missions do not.

> *I think it's inspiring…and it is exciting when you have somebody from your home nation doing something. It's a bit like in the World Cup. [It] is really interesting whilst England are playing and then when they are not it's not as exciting. In terms of having somebody speaking the same language, he's brilliant.*
>
> Key informant S, teacher

However, some key informants questioned the significance of a British astronaut for meeting science and public engagement aims. Drawing on comparisons between the Philae lander and the *Principia* mission, one interviewee reported that it was possible to achieve the same scientific and technological aims using robotic missions and questioned the extent to which human spaceflight confers additional benefits that justify the additional cost. A second interviewee noted that if education were the primary aim of the mission, the money might be better spent elsewhere.

> *You don't need an astronaut to do that [take seeds into orbit]…by having an astronaut you put at least one zero on the cost…what value the astronaut is bringing isn't entirely clear to me.*
>
> Key informant M, scientist

Although several interviewees referred to the '*Apollo* effect' on uptake of science in the USA and were hopeful of a similar (if less pronounced) *Principia* effect, the differences in society and culture were noted. One key informant questioned the importance of having a British astronaut in space when young people were able to personally connect with news and images of astronauts via social media.

One key informant saw the possibility of the human element in drawing attention to the hard work and training that needs to be done in advance.

> *I think it's brilliant to celebrate British science and the industry, but I think we also need to celebrate the everydayness of science, that it's all around us all the time and it's not about dumbing it down. It's just about saying it comes in lots of flavours.*
>
> Key informant S, teacher

Potential benefits of human spaceflight and the Principia mission

A number of benefits of human spaceflight were identified by interviewees. These included:

- *Scientific gains* The opportunity to do excellent science, to contribute to the ESA human spaceflight programme through ELIPS and other components, to develop technology and to access the International Space Station. This includes downstream applications of space science technology including data services, telecommunications, Earth observation and GPS data as well as knowledge gained now that could take humans out of low Earth orbit to the Moon or Mars in the future.
- *Economic gains* Several key informants saw the *Principia* mission as an opportunity to highlight the quality of work done in the UK and to raise the profile of economically successful British space activities (including the work of the UKSA and space-related industries) nationally and internationally. For example:
  We need to use this one-off opportunity we have…to showcase the success story of the wider world class UK space sector. (Key informant O, science education director.)
- *Educational gains* These were identified to include the opportunity for young people to contribute to Tim Peake's activities in space (e.g. writing code that will be used on the

Raspberry Pi, growing the rocket seeds), to develop educational resources for children and teachers that can be used for the next 10 years, and to gather evidence in relation to the educational impact of human spaceflight on young people.
- *International collaboration* Interviewees saw the *Principia* mission as an opportunity for scientists and astronauts from different nations to work together across political divides.

Potential drawbacks of human spaceflight and the Principia mission

Some potential drawbacks to the *Principia* mission were identified. These included the following:
- Expense of putting a human into space compared with other ways of collecting data to advance knowledge (e.g. Earth based astronomy and robotic missions).
- Time available to plan and incorporate *Principia* related activities into curriculum and to find ways of communicating with schools.

One key informant noted a possible negative impact of the research relating to the impact of human spaceflight on students' responses to STEM subjects. This interviewee expressed the view that the mission is motivated by desire to get more children into STEM rather than scientific objectives, so if this effect is not significant, or is negative, the mission has the potential to have negative impact on space science more broadly.

5.3 The *Principia* mission and STEM education

This section reports on key informants' views of the importance of the *Principia* mission in relation to STEM education including their views on the research into students' responses.

Most key informants were involved in a range of STEM education and outreach activities, and many observed that their professional activities were based on the assumption that space is an inspirational context for learning. These included the following types of activity.
- Public lectures
- Mentoring programmes
- Space schools
- Astronomy clubs and societies
- Masterclasses and 'design and build' days
- STEM clubs
- Social media activity
- Careers conferences
- Engineering education schemes
- Authentic research projects linking schools and universities
- Development of Massive Open Online Courses (MOOCs)
- Production of planetarium content
- Science centre and museum education
- Teacher continuing professional development (CPD)
- Resource creation and dissemination and curriculum development
- Membership of governing body at Space Studio school
- Consulting on BBC television and radio programmes

In addition, a number of *Principia*-themed activities and events had been planned by the key informants and their associated organisations. Several interviewees discussed the idea of a resource bank, and advised that if this was to happen, it should be prepared such that it has global rather than local (English) applicability and should be organized to include information in relation to the resource, such as a plan for use, description of the nature of the activity, intended audience, where found and other relevant information.

5.4 Perspectives on the *Principia* mission and STEM education

Most key informants were positive about the potential STEM educational impact of the *Principia* mission, although some questioned whether it would be possible to attribute any impact to human spaceflight rather than to space science and astronomy more generally. A number of potential educational benefits were identified. These included:

- Generating a sense of wonder and inspiration around science, as one key informant put it:
  Space is a gateway drug into science (Key informant B, scientist.)
- The opportunity to use space and human spaceflight as a context for teaching STEM and other subjects:
  It's about using the context across numeracy, literacy, science and maths (Key informant C, science education director.)
- Raising awareness of a range of careers in STEM, particularly for those from under-represented backgrounds. This was often mentioned as a way of increasing number and/or quality of people employed in the space sector.
- Raising awareness of high-tech industries.
- Promoting messages to young people such as:
  … *that it is good to be adventurous, brave, and try something new* (Key informant P, science education director).
- To provide a new perspective on Earth, in particular in relation to environmental issues such as climate change.

Although no drawbacks of human spaceflight on responses to STEM subjects were identified *per se*, a number of challenges to achieving the educational aims of the *Principia* mission were identified. Most of these related to work with schools and teachers. These included:

- Schools are not necessarily aware of/engaged with educational materials and activities that have already been promoted. One interviewee expressed concern that the community (space science and space education) is talking to itself well, but not more widely, and another observed that teachers need to be convinced that it is worth putting the time aside to find and use existing resources. One of the teacher interviewees reported that they had little time to search for material or to be involved with some of the organized activities, e.g. radio communication with the ISS.
- The importance (and difficulty) of engaging teachers. One interviewee attributed this to perceptions amongst some primary teachers that science is '*difficult and scary*' *(*Key informant S, teacher).
- Curriculum time and content, e.g. in the primary curriculum in England one key informant noted that there was not much about space, but the 'working scientifically' strand provides a way for teachers to teach the curriculum in the context of space.
- Related to the curriculum, interviewees identified issues around timeliness, including when space is taught in the year and whether or not this coincides with the launch date and activities planned.

Many of the challenges identified related to working with teachers, though those in the informal science education sector identified the key role that families may play in promoting engagement with and uptake of STEM subjects. One key informant described the importance (and difficulty) of engaging parents.

> *[Teachers] are not the most powerful actors in this, it's the families…so if we can get the parents to get more involved and seeking out opportunities and telling kids about it, we can change.*
>
> Key informant P, science education director

5.5 Aspirations for research into the impact of human spaceflight on young people's attitudes to STEM subjects

Key informants were asked about their views on the research on the impact of human spaceflight on students' responses to STEM subjects.

The link between human spaceflight and responses to STEM subjects

One of the most common educational aspirations for the mission related to generating evidence, in a robust and rigorous way, about whether or not a causal link between human spaceflight and attitudes towards STEM subjects exists. Interviewees reported that evidence on the impact would be useful in a range of situations from informal and formal learning environments to policy-making situations. There was also considerable appetite for analysis comparing responses of girls and boys, and those of students from different socio-economic backgrounds at different times (immediately at launch but also during and post-flight).

Informants differed in their ideal levels of measure of response to STEM subjects. Some respondents favoured measures at the level of *awareness* that British astronaut was in space. Others favoured outcomes linked to formal education systems such as attainment in science at GCSE, choice of post-compulsory science (e.g. A level or Highers) and entry to STEM degrees or employment. Others favoured measures of participation in mission-related events such as participation in social media and attendance at science centres.

A number of notes of caution were struck about the research, particularly the need to recognise the difficulty in distinguishing between Tim Peake personally, human spaceflight more generally and space science and astronomy for young people, and the need to ensure that schools with varying degrees of involvement in the mission are included in the sample.

Some key informants suggested further questions worthy of exploration, including teachers' attitudes to science, space and teaching and in particular investigating the link between the teachers' ability to make better STEM education experiences for students and the *Principia* mission, because

> *I think you've got to make sure that you can change the teachers, and if you change the teachers, you change the kids.*
>
> Key informant O, teacher

Finally, some interviewees were interested in the legacy of the mission, and were interested in longer-term follow up of students, to include attainment and post compulsory science education choices.

5.6 Views on the map of resources

There was a range of views on the usefulness of a resource map. A number of resource banks were highlighted, including the EAAE, National STEM Centre, ESERO, the European Southern Observatory and NASA, as well as activity on traditional and social media and the activity of ambassadors (STEM ambassadors and space ambassadors).

Some interviewees observed that some of the resource sites were archives of material such as lesson plans rather than videos and information that teachers can then put into context for their learners, or featuring live updates and countdowns to action. Common to the teacher respondents was an identified need for resources that celebrate the science that helps get people into space, for example capturing the stories of some of the people that make it happen, not limited to the story of the astronaut. For example:

> *Where's the person who refuels…the rocket? Who's the person who makes sure it doesn't explode, and … the people who do the countdown, and the secretary? I think there's so much out there but it's always just creamed off the top and it's like eating the icing off the cake which is lovely, but where's the everyday science?*
>
> Key informant O, teacher

Section 6: Attitudes to STEM survey

6.1 A note about the survey data

This section presents and discusses the baseline data from the attitudes to STEM survey. At the point of writing this report, the analysis of the answers to the fixed-response items is complete, but a more detailed analysis of the open responses items has yet to be undertaken.

Additionally, one of the principal aims of the RISES project is to compare students' responses before and after the *Principia* mission. Thus the baseline data does not contain any detailed statistical analysis. Where there are notable differences in the data (e.g. between responses from primary and secondary students), these have been tested for significance in case they point to particular areas worth exploring in interviews.

6.2 Survey development and piloting

The RISES Attitudes to STEM survey for secondary school students comprises of separate sections for each of the four STEM subjects (Science, Technology, Engineering and Mathematics), as well as one concerned with space. The sections are modelled on existing instruments as far as possible, taking their main cues from the sources described in Section 3.2. The order of the subject sections (Science Mathematics, Space, Technology, Engineering) was chosen so as the gain the most consistent and complete data for the sections which are expected to raise the most interest from the international community, keeping in mind that attitudes to technology and engineering have received less attention in the literature so far and were presumed to be much more difficult to disentangle from the rest and each other. Additionally, if respondents were not able or willing to complete the full instrument, it was seen as desirable to ensure data on space science was gathered, hence this section was not put at the end.

A similar number of similar disposition statements were developed for each of the sections, covering seven areas of interest:

- Subject inside school
- Subject outside school subject lessons
- Career in the subject
- Perceptions of the value of the subject
- Impact of the subject
- External influences
- Confidence in/perceived difficulty of the subject

In addition, each section contains a small number of open questions related to students' personal experience of and interest in each of the subjects (taking space as a fifth subject in this context), along with their knowledge and experience of their school's STEM-related clubs. The full survey for secondary school students has 119 questions/statements, with the disposition statements rated through a five-point Likert-type scale (from ‘agree a lot’ through to ‘disagree a lot’).

The primary school survey was shortened and simplified in two ways: the Likert-type scale was reduced to a three-point scale, and the Technology and Engineering sections were collapsed into one, in which ‘Designing and Making’ was used as the overriding title, because this is the curriculum area in which technology and engineering are covered in primary schools. The full survey has 99 questions/statements, with the terminology in the science, mathematics and space sections largely identical to that in the secondary school survey.

The surveys were piloted in four secondary schools and five primary schools, with a year group representing the same age group as the ones who would be completing the main survey in the following academic year, hence not yet using the target population. Almost all pilot schools subsequently took part in the main survey. The survey was mainly conducted electronically, in school lesson time. For the first phase of the main project, three schools requested paper copies of the surveys for their students to complete, also in lesson time.

Principal Components Analysis showed the survey to perform well: very few items, if any, created outliers; internal consistency, as judged by Cronbach’s alpha, was high (>0.90), and patterns of missing data were as expected (with more missing data towards the end of the survey as respondents run out of time, but no systematically missing data in earlier sections).

6.3 The quantitative baseline (Phase 1) survey data

Overview

The survey data comprised 797 responses from students in 23 primary schools and 1600 responses from students in secondary schools.

Likert-type items for secondary school responses were coded 1-5 with 5 representing the most positive attitude. Similarly, the primary school responses were coded 1-3. Where comparisons are made between primary and secondary school responses, the secondary school responses have been grouped so that ‘agree a lot’ and ‘agree a little’ become a combined group of ‘agree’, coded 3 as for the primary school responses (and similarly for the ‘disagree a lot’ and ‘disagree a little’ together coded as 1).

A binomial test of the primary school data indicated that the proportion of boys of 0.48 is not significantly different from that expected (0.50) in the general population, $p=.314$ (2-tailed). The secondary school data are also not significantly different from the expected 0.50 in the general population, with the proportion of boys of 0.54 ($p = 0.003$; 2-tailed). Participants were given the option not to answer the question about gender, which a small proportion has taken up (3% at primary age, 0.5% at secondary age).

6.3.1 General responses to studying STEM subjects

Science is viewed very positively as improving people’s lives

Both at primary and, perhaps, even more so at secondary school, participants are happy to report that they think science is generally a good thing. They also appear positive about how technology and engineering might make everything work better, but their views of the contribution of mathematics to people’s lives are not as positive.

Table 1 shows that that the mean score for each of the school samples for each of the statements is significantly above the middle option (2=neither agree nor disagree), e.g. for secondary school students talking about mathematics the mean is 2.11 ($t(1551) = 5.696$; $p = 0.00$). Degrees of freedom are always (N-1), with N being the number of respondents who gave a valid answer.

Students' confidence about their abilities in science and maths is about the same in the primary and secondary age ranges

The proportion of students who think they are good at science and maths is similar in primary and secondary schools, with the mean score for primary school students being 2.25 and for secondary school students being 2.29 (for t and p, see Table 2). A small minority of students both at primary and at secondary school report that they are poor at both subjects.

Students are less confident about their abilities in engineering (explored in the secondary school survey only). This may well be explained by their lack of confidence about what the subject entails, as none of them have dedicated engineering lessons at their age.

Table 1: Students' views of the value of STEM for everyday life and society

	Primary school				*Secondary school*			
Statement	N	mean	t	p	N	mean	T	p
Scientists help make people's lives better	790	2.57	26.712	0.00	1582	2.64	39.745	0.00
Mathematicians help make people's lives better	779	2.27	10.267	0.00	1552	2.11	5.696	0.00
Technology and engineering can improve things that people use every day	767	2.63	29.438	0.00				
Technology and engineering makes everything work better	764	2.57	26.011	0.00				
Technology makes our lives better					1562	2.62	38.015	0.00
Technology makes everything work better					1536	2.57	33.967	0.00
Engineering can improve things that people use every day					1538	2.55	31.636	0.00
Engineering offers the chance to change the world for the better					1519	2.43	23.721	0.00

Table 2: Students' confidence in their STEM-related ability

	Primary school				*Secondary school*			
Statement	N	mean	t	p	N	mean	t	p
I am good at science	790	2.25	10.619	0.00	1582	2.29	14.792	0.00
I am good at maths	781	2.49	20.608	0.00	1577	2.40	20.504	0.00
I am good at engineering, designing and building things					1503	2.17	8.190	0.00

When comparing the frequencies of students' responses to questions about their ability in science and mathematics, it becomes clear that the higher than average confidence rating overall belies the underlying distribution. Upper primary age students seem particularly unsure about their ability in science (see Table 3). Confidence in ability in mathematics is encouraging, both at primary and secondary school.

6.3.2 Views of careers involving STEM subjects

More lower secondary age students expect to use science and maths in their jobs than primary age students

Lower secondary age students believe they will need to use science, technology and, especially, maths in their jobs (mean score for the latter is 2.35 at primary age and 2.47 at secondary age (see Table 4). Only a small minority think they can have a job which does not involve maths (see Tables 5 and 6). Again the figures engineering may reflect a lack of understanding of what might be involved.

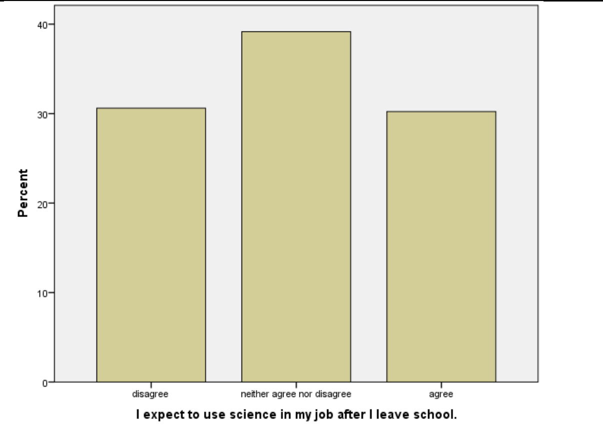
Table 3: Comparing frequencies of agreement with statements about STEM-related ability

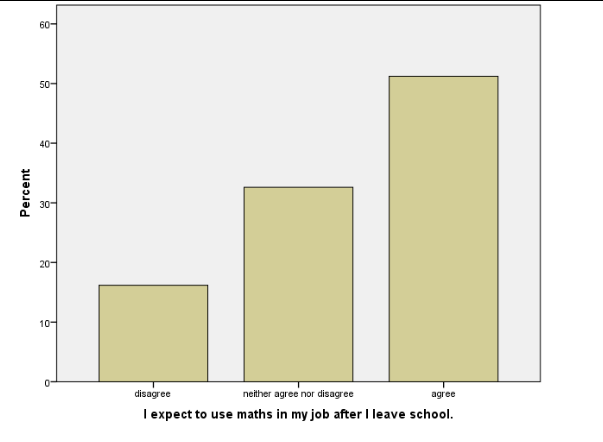
	Disagree (%)	*Neither agree nor disagree (%)*	*Agree (%)*
I am good at science			
Primary school	13.0	47.8	38.3
Secondary school	20.1	29.8	48.9
I am good at maths			
Primary school	9.3	31.5	57.2
Secondary school	18.2	22.4	57.9

Table 4: Students' expectations of STEM in future jobs

	Primary school				*Secondary school*			
Statement	N	mean	t	p	N	mean	t	p
I expect to use science in my job after I leave school	784	2.00	-0.137	.891	1588	2.01	0.293	0.770
I expect to use maths in my job after I leave school	785	2.35	13.212	0.00	1589	2.47	24.922	0.00
I expect to use technology in my job after I leave school					1563	2.25	11.940	0.00
I expect that designing products (e.g. hip replacements) or structures (e.g. bridges) will be important in my job after I leave school	768	1.98	-0.558	0.577	1536	1.86	-6.611	0.00

Table 5: Frequency distributions of primary school students' expectations of using science and mathematics in their future jobs





These differences are statistically significant: p=0.002.	These differences are statistically significant: p=0.001

Lower secondary age students are clearer about the careers they want to follow than upper primary students, and careers involving technology are popular

Lower secondary age students are more willing to commit to saying whether they see a future in STEM careers for themselves or not (evidenced by considerably fewer choosing the middle option, see Table 8), whereas primary age students seem a lot more unsure. Interest in STEM careers on the whole is not encouraging, however, and it seems even lower in the secondary than in the primary age group, with the possible exception of careers involving technology (see mean scores in Table 7, which are below the middle option apart from for technology at secondary school age and 'designing and making' for the primary school age group).

Table 6: Frequency distribution secondary school students' expectations of using STEM in future jobs (grouped categories for comparison with primary school students' responses)

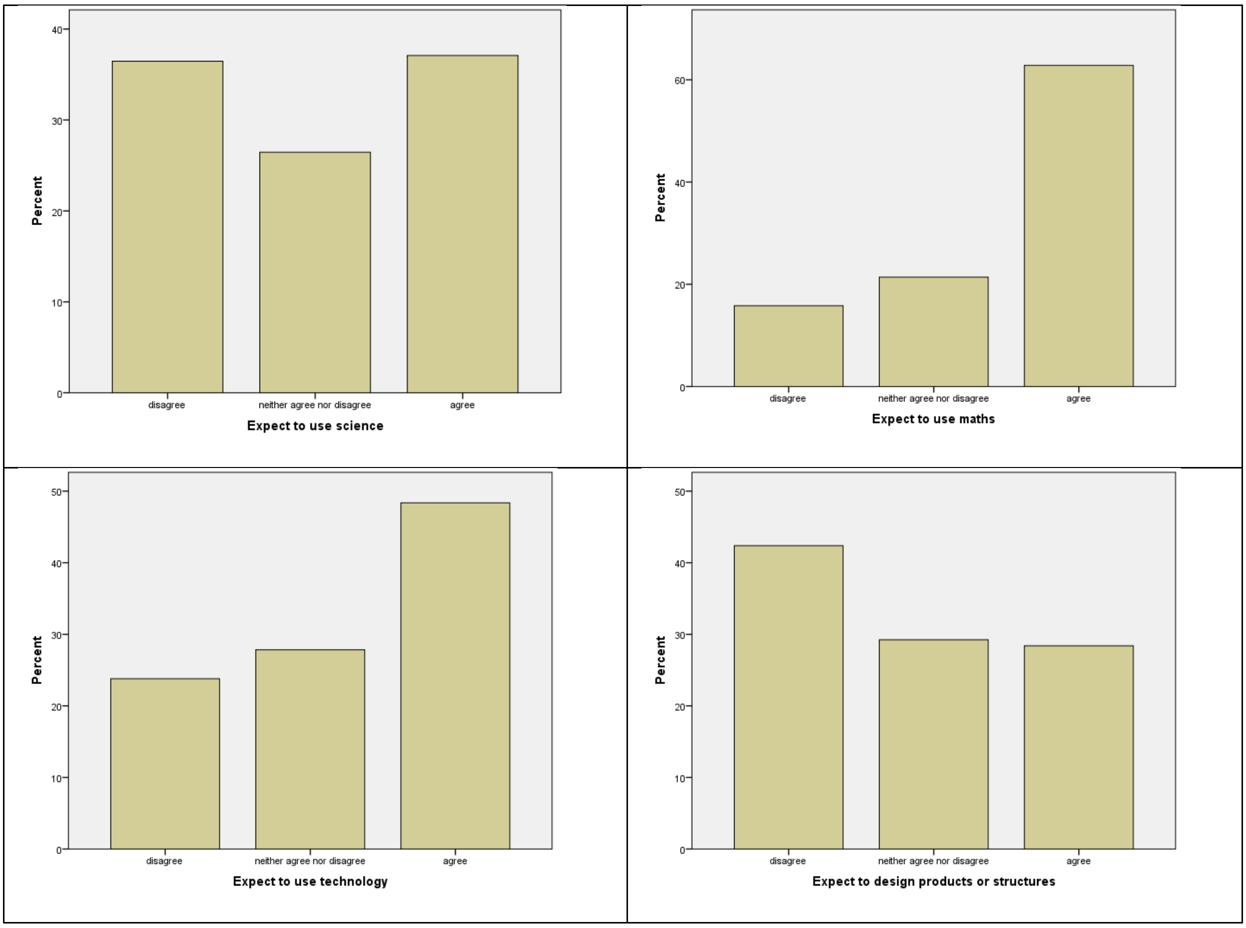


Table 7: Students' views of STEM careers

	Primary school				*Secondary school*			
Statement	N	mean	t	p	N	mean	t	p
I would consider a career as a scientist	789	1.77	-8.616	0.00	1587	1.73	-12.621	0.00
I would consider a career as a mathematician	788	1.85	-5.620	0.00	1591	1.63	-18.680	0.00
I would like to have a job related to space science or space technology	784	1.89	-3.857	0.00	1580	1.78	-10.189	0.00
I would consider a career in which technology is the most important part					1561	2.05	2.528	0.012
I would consider a career in which 'designing and making' is the most important part	766	2.09	3.412	0.001				
I would consider a career					1534	1.89	-4.795	0.00

in engineering								

When comparing frequencies of students' responses to questions about careers (see Table 8), there is a downward trend between the primary and secondary school age groups, notably for careers in which science and mathematics feature heavily. Half of the secondary school students seem already to be turning away from those potential careers. Technology (at secondary school level) and 'designing and making' (at primary school) fare rather better, with only around a quarter of students disagreeing that a career in those areas might be for them. Numbers for engineering (at secondary school) are somewhere in between, which may again be a reflection of a lack of understanding of what may be involved. A potential career in designing and making may be easier to imagine for an upper primary school student than a potential career in engineering is for a lower secondary school student.

Table 8: Frequency distributions of students' views of STEM careers (1=disagree, 2=neither agree nor disagree, 3=agree)

	Primary school			*Secondary school*		
Statement	1 (%)	2 (%)	3 (%)	1 (%)	2 (%)	3 (%)
I would consider a career as a scientist	42.4	37.1	19.4	52.3	21.3	25.7
I would consider a career as a mathematician	36.1	41.4	21.3	56.8	22.9	19.8
I would like to have a job related to space science or space technology	37.1	34.9	26.3	48.2	23.8	26.8
I would consider a career in which technology is the most important part				30.4	31.6	35.6
I would consider a career in which 'designing and making' is the most important part	23.1	41.0	32.0			
I would consider a career in engineering				41.3	23.5	31.1

6.3.3 Responses to learning about space and spaceflight

Space science is seen as making a worthwhile contribution to people's lives

Students were asked whether 'Space science makes lives on Earth better', which produced a very positive response, along with similar questions about the importance of human spaceflight (see Table 9). This seems an area for further exploration in interviews in order to find out what students already know about the research that goes on in space science, and the impacts this may have on their lives.

It is also notable that the space section of the survey achieved nearly 100% response rate, similar to most of the Science and Mathematics section. Response rates decreased noticeably after the space section.

Table 9: Students' views of the value of space science and technology

	Primary school				*Secondary school*			
Statement	N	mean	t	p	N	mean	t	p
Space science makes lives on Earth better	786	2.38	15.631	0.00	1579	2.16	7.744	0.00
It is important to send people into space to find out more about the universe	782	2.59	26.614	0.00	1578	2.56	31.521	0.00
Sending humans to space is worth the money spent	784	2.33	12.567	0.00	1573	2.30	15.076	0.00

There is a belief that you need to be clever to have a job involving space science

There is a belief that you need to be clever to do a job in space science or technology (primary mean score 2.43 and secondary 2.54). This is even more apparent for space than for other STEM subjects, and even exceeds maths for the perceived need for cleverness (primary mean score 2.16 and secondary 2.21).

Questions were asked about the perceived need for being clever or being good at certain aspects in each of the five sections of the survey. On the whole, it seems primary school students do agree, but secondary school students do not agree, that abilities in maths and science are a prerequisite for a successful future in technology and engineering (see Table 10). They are, however, all fairly sure that you need a combination of knowledge and skills, including dexterity, to succeed in these subjects.

Table 10: Students' views of the perceived need for certain abilities to have a STEM-related job

	Primary school				*Secondary school*			
Statement	N	mean	t	p	N	mean	t	p
You need to be clever to be good at science	790	2.08	2.791	0.005	1581	1.95	-2.209	0.027
You need to be clever to be good at maths	777	2.16	5.708	0.00	1576	2.21	10.510	0.00
You need to be clever to do a job in space science or space technology	787	2.43	16.752	0.00	1577	2.54	30.359	0.00
You can study technology and engineering only if you are good at maths and science	751	2.19	6.866	0.00				
You can study technology only if you are good at maths and science					1530	1.81	-9.372	0.00
You can study engineering only if you are good at maths and science					1501	1.87	-6.393	0.00
If you want to be good at 'designing and making', you need to be able to use your brain and your hands	754	2.66	32.408	0.00				
If you want to be good at technology, you need to be able to use your brain and your hands					1540	2.55	32.069	0.00
If you want to be good at engineering, you need to be able to use your brain and your hands					1504	2.44	23.633	0.00

Learning about space is popular in school, but perhaps even more so outside of school

Both inside and outside school space is a topic of significant interest, as demonstrated by students' responses to questions about their interest in human spaceflight and technology needed for spaceflight as a whole (see Table 11). The positive attitudes are particularly pronounced in the primary age group.

Table 11: Students' views of learning about space

	Primary school				*Secondary school*			
Statement	N	mean	t	p	N	mean	t	p
I enjoy learning about space in school lessons	786	2.65	29.698	0.00	1579	2.41	20.967	0.00
I enjoy finding out about space	782	2.69	31.944	0.00	1582	2.45	22.797	0.00
I am interested in what happens to humans in space	788	2.67	31.378	0.00	1583	2.48	25.044	0.00
I am interested in the technology which is needed for spaceflight (e.g. rockets, satellites, the International Space Station)	780	2.49	19.927	0.00	1565	2.28	13.648	0.00

Many students would like to be astronauts

When it comes to the possibility of travelling to space, half the student population is clear that they view this very positively, even though they are not as positive about having a job involving space science or technology. There is also a large number of students who would definitely not want to travel to space.
On average, secondary school participants agreed that they would like to travel to space: $t(1575) = 7.734$, $p = 0.00$ (the 95% confidence interval of the difference brings it to between 2.13 and 2.22, which is significantly above 2.00).

Participants were less positive about wanting a job related to space science or space technology: $t(1579) = -10.189$, $p = 0.00$ (95% interval 1.74-1.83). When asked whether they felt confident that they could work in space science or space technology if they wanted to, the picture was a little more positive again, although not significantly different from the hypothetical average of 2.00: $t(1569) = -1.719$, $p = 0.086$ (95% interval 1.92-2.01).

At the primary school age, the students are almost equally positive, on average, about wanting to travel to space: $t(784) = 5.203$, $p = 0.00$ (95% interval 2.10-2.22). Again, their interest in a job related to space science or space technology does not follow their desire to travel to space: $t(783) = -3.857$, $p = 0.00$ (95% interval 1.83-1.95). Their confidence that such a job might be attainable for them, however, is recognisably higher than that for secondary school students: $t(784) = 6.265$, $p = 0.00$ (95% interval 2.12-2.23).

Looking at the desire to travel to space in more detail (see Table 12), there is a pronounced polarisation in responses: while around half the sample agrees, both at primary and secondary age, almost a third is adamant that they do not want to travel to space, with a significantly smaller proportion undecided. Boys in particular are positive about the prospect, and the divide between boys and girls is especially pronounced in the secondary age group.

Table 12: Frequency distributions of students' responses to the question about space travel

The differences displayed in this table are significant (p = 0.01 or less).

	Disagree (%)	*Neither agree nor disagree (%)*	*Agree (%)*	*Total (number)*
Secondary school				
Total	32.6	17.3	50.1	1568
Boy	22.6	15.2	62.2	846
Girl	44.3	19.7	36.0	722
Primary school				
Total	30.4	22.9	46.8	761
Boy	25.8	22.2	52.1	365
Girl	34.6	23.5	41.9	396

6.3.4 Views of school STEM-related clubs, including space clubs

In each section of the survey, students were asked whether the school had a club relating to the subject of the section, whether the student liked attending the club if there was one, and what kind of activities take place (for the latter, see Section 6.4). Table 13 shows the majority answers to the questions about whether a club exists.

There is some confusion about STEM-related clubs in schools, as students from the same class may think there is no club, while others in their class are adamant there is, and describe activities that go on there. There are very few schools where any of the majority answers in Table 13 was given by 100% of the students, and it is not uncommon for the answers to be spread almost equally among the three categories. Secondary schools students in particular do not seem aware of whether certain clubs exist.

Table 13: Frequency distributions of majority responses to the questions about the existence of STEM-related clubs in schools

	Primary school				*Secondary school*		
	No	I don't know	Yes	Equal yes/no	No	I don't know	Yes
Science club	15		8		2	2	14
Maths club	18		4	1	4	10	4
Space club	21		2		7	8	3
'Designing and making' club	13	1	6	3			
Technology club					2	12	4
Engineering club					7	10	1

The qualitative responses (see Section 6.4) help explain some of the patterns in the data on clubs.

There is suggestion in the qualitative data that some students see remedial and/or revision classes, outside normal lesson time, as clubs, whereas others perhaps do not.

It is likely that students categorise technology and engineering clubs in different ways, so the numbers of those clubs in schools are difficult to deduce from the data.

Some students would like to go to a club but it does not exist (to their knowledge), whereas others would like to go to a club but it is only for older or younger students or some other subset of students to which they themselves do not belong.

At secondary school in particular, it is not uncommon for a student to know a certain club exists (and therefore answering 'yes' to that question), but their positive answer being followed by a very negative response to the question about their attendance and the type of activity that takes place.

The primary age students are much more positive about attending their schools' STEM-related clubs. For science and mathematics clubs the three categories each receive around one-third of the total number. 'Designing and making' clubs achieve slightly higher ratings with 43.5% agreeing they like to attend (compared to 230.0% disagreeing and the rest choosing the middle option), while enthusiasm for space/astronomy clubs is greatest: 60.6% likes to attend, with only 18.3% disagreeing. The numbers quoted are all significant deviations from the mean score ($p = 0.00$). The numbers of primary school students answering these questions are as follows (keeping in mind they were only shown the statement/questions if they answered 'yes' to the question about the club's existence):

Table 14: Sample of primary school students answering questions about STEM-related clubs

	I like to attend our school science club	I like to attend our school maths club	I like to attend our school astronomy/ space club	I like to attend our school 'designing and making' club
N	283	144	104	269

Influences from parents/carers, peers and teachers

The influences of the home environment, peers and teachers were investigated in a number of ways. Analysis of these data is in progress.

Teacher influence was probed through statements such as ‘My science teachers make me more interested in science’, and ‘the things we do when we are learning about designing and making make me more interested in technology and engineering’ (and similar statements for other STEM subjects).

Peer influence was explored through ‘My classmates think science is interesting’ and related statements for the other STEM subjects.

Parent/carer influence was probed through ‘My parents/carers think maths is interesting’, and ‘I like to talk to someone in my family about what I have done and learnt about technology at school’ (and related statements for the other STEM subjects). In addition, the introductory section of the survey contains questions to gather some data about socio-economic status (SES) such as ‘Is there a personal computer, laptop or tablet in your home, for you to use?’, ‘How many books are in your home?’ and ‘Do you have any family members who work or study for something to do with [STEM subjects]?’, which probe the family aspects of students’ science capital.

Experiences of out-of-school learning, whether with a school or family group, were investigated through statements such as ‘I like to visit a science centre or science museum’ and ‘I like going to a factory or other engineering workplace to see what engineers do’.

6.4 The qualitative baseline (Phase 1) survey data

Introduction

Free responses were sought through five questions:

- If there are adults in the home with STEM-related education and/or jobs, who are they and what do they do?
- What do students do at each of the STEM-related clubs at school?
- What do students remember learning about space in the last year or so?
- What do the words ‘science’/’mathematics’/’technology’/’engineering’ make students think of, and what would they like to learn in lessons related to these subjects?
- Which technology lessons do students have in school? (secondary school only)

In the following discussion, all quotations from students are reported as written by the students.

Relatives with STEM-related education and/or jobs

291 out of 797 primary school students (36.5%) and 554 out of 1215 secondary school students (45.6%) answered ‘yes’ to the question whether they had relatives with occupations involving STEM. Siblings, parents, grandparents, aunts and uncles were mentioned, with occupations such as teachers, doctors, accountants, mechanics, engineers and many more.

Examples of responses include:

> *My dad is in engineering and my mum does work for the stations and trains but she use to build tanks.* (Girl, primary)

> *My Grandpa is a Scientist, My Uncle Is a Lawyer, My Aunt Is a Lawyer*. (Boy, primary)

Both of my parents are doctors. My sister is training to be a psychologist. Everyone on my mums side are doctors. (Boy, secondary)

I have some family that works in a hospital and my granddad fix's things that we bring to him like technology! (Girl, secondary)

My brother is studying natural sciences. My uncle and dad work for the NHS. My grandad and grandma are vets and so is my other uncle. (Boy, secondary)

STEM clubs

Some issues related to STEM clubs have become apparent:

- There is a small but recognisable number of students (both at primary and at secondary school) who see remedial and/or revision classes, outside normal lesson time, as clubs, whereas others perhaps do not;
- It is clear that some students would like to go to a club but it does not exist whereas others would like to go to a club but it is only for older or younger students or some other subset of students to which they themselves do not belong. This is mentioned by numerous students in two primary schools and one secondary school;
- Particularly at secondary school it is not uncommon for a student to know a certain club exists but their positive answer being followed by a very negative response to the question about their attendance and the type of activity that takes place. This accounts for a significant proportion of the negative responses.

What is a STEM club?

Is a STEM club always a fun extra? At least some students certainly seem to appreciate the additional support they receive in extra-curricular gatherings related to science and mathematics in particular. 'Technology club' in secondary school may also be like a lesson catch up session. This is borne out in occasional comments like:

We can do revision for tests and learn more about are topic and we can do amazing practicals. (Boy, secondary)

I would learn maths and try very hard on what they give me and if they give me homework then I would do it and make sure I don't lose my homework. (Girl, primary)

In maths clinic we go through things we are finding difficult 1-1. (Girl, secondary)

Learn and talk about the new technology and finish are [technology] practical's. (Boy, secondary)

This phenomenon is likely to be the result of schools and teachers using the word 'club' for their remedial/additional support classes.

Clubs that do not exist or which are for a select few

In the survey statement about liking to attend a club and the accompanying probe of the club's activities are only shown to respondents who have indicated that such a club exists. However, some students have gone to the trouble of answering 'yes' to the question about the existence of a certain club, in order for them to be able to indicate that they would have liked to attend a certain club were it to exist.

Others use the probing section to describe that they went last year but the club no longer exists or is only for the lower age group or higher age groups.

> *I can not go because it is only for Years 3 and 4*. (Boy, primary)

> *I don't go because it is only for GCSE level (Year 9 +) but I would love to go.* (Girl, secondary)

Non-participation in STEM clubs

'Disagree a lot' as a response to the statement about liking to attend a certain STEM-related club is the largest category of responses for all STEM clubs in the secondary schools. It is commonly followed by 'I don't go' when the clubs' activities are probed, which, when elaborated upon, turns out to be simply because the students are not interested in attending. In a small number of cases more direct reasons are put forward for non-attendance, for example:

> *I would like to go but I have to attend a flute class.* (Boy, secondary)

> *I don't want to go because of the teachers.* (Boy, secondary)

> *I don't go as it seems to always clash with other clubs that I go to*. (Girl, secondary)

'I don't go' is also mentioned by primary school students, but on the whole they are rather more positive about their schools' STEM-related clubs.

> *I don't go because I don't have enuf time.* (Girl, primary)

> *I don't go but I know they do experiments like how long it takes for a plastic bag parachute to hit the floor but adding more weight like a paper clip each time. They also do a lot of things to do with forces.* (Girl, primary)

STEM club activities

More constructive mentions of activities at STEM-related clubs include:

> *I am in a group called the healthy living group we make sure that children are eating healthy*. (Girl, primary)

> *I would do a recycaling job because I would like to help the enviorment.* (Girl, primary)

> *Lots of experiments we wouldn't do in class.* (Boy, secondary)

> *Look after the turtles snails and chicks, experiments, blowing up stuff, making crystals* (Girl, secondary)

> *Challenges, partner stuff, problem solving, dice work, cards, games* (Girl, primary)

> *our space club is called space academy were we train to be astronauts. I am in this club and it gives me a great attitude to learning about space. In our space club we do missions and every mission we complete we get points for it, after we compare our points to other schools points and see which school has the most points.* (Girl, primary)

We look at programming and python [in section about engineering club]. (Boy, secondary)
We build structures out of paper and had to support an egg on top. (Boy, secondary)

What students learned about space

The National Curriculum for England does not have a requirement for teaching about space, and the topic is therefore not necessarily on a school's curriculum. Some teachers bring space-related activity into many more lessons than is required of them through the National Curriculum. Students in some schools were already well aware of Tim Peake and his mission at the time of the baseline survey, and some students did not need their school to bring him to their attention. In contrast, there are schools where students had not come across Tim Peake.

Student responses to the item 'Please tell us what you have learnt about space in the last year, both in and outside school' include:

> *I have learnt that if you want to go into space you need a lot of training for example you have to wear a very heavy spacesuit in space so they wear the spacesuit and walk in water.* (Girl, primary)
>
> *Space is a very dangerous and it takes a lot of braveness to go to space*. (Girl, primary)
>
> *Well we havent really done a lot about space in side of shool but I would like to do a little bit more of it.* (Girl, primary)
>
> *If you take your space helmet of you wont be able to breathe and have a possibility of dying.* (Girl, secondary)
>
> *I have learnt that a space suit for the Moon would be diffident than a suit for Mars*. (Boy, primary)
>
> *I had heard about Tim Peake before school. We never learn't about him. We did lean about planets and galaxies and black holes and dark matter.* (Boy, primary)
>
> *I heard about tim peake on news rond*. (Girl, primary)
>
> *There is a non manned rocket near pluto.* (Boy, secondary)
>
> *We have looked at life on the ISS and on a school trip to the National Space Centre in leister we did a workshop about rockets.* (Boy, secondary)

STEM words and desirable topics

At the start of every section of the survey the respondents were presented with a brief description of the kind of knowledge and understanding that might be related to the section subject, along with some information about jobs and careers. This was followed by two invitations for students to share their thoughts on what the STEM word means to them, and which single topic they would most like to learn about in the related lessons at school. Box 1 uses Science to illustrate what students were asked to do.

These sections were included in the survey to check that there was reasonable similarity between the views of the research team and the views of students of what comprised each of the four STEM subjects. The research team felt that there was likely to be a good correspondence for Science and Mathematics, but there were likely to be more differences for Technology and Engineering.

Preliminary scrutiny of the responses indicates that they are very rich and varied, and will provide good insights into students' views of STEM subjects. There are many examples of considered, thoughtful and extensive responses, though some students have not provided very sensible answers. A more detailed analysis has just started, and this will be reported in full in the second project report.

Box 1: Science

Science is: observing and experimenting with the world around us, to give us knowledge and understanding about how our world, including everything in and around it, works.

Jobs and careers directly using science might be: conservation manager, researcher, veterinary scientist, astronomer, fisheries inspector.

When I think of the word 'science', I think of:
Please give at least three things, but write as much as you like.

In science lessons, what I would most like to learn about is:
Please write the one thing that you can think of most easily.

Technology lessons

Given the diverse ways in which students are likely to encounter 'Technology' in and outside school, secondary school students were asked to provide a list of the technology lessons they have at school. These cover the ones commonly offered in Design & Technology departments, as well as Information and Communications Technology (ICT), although many students restrict their answer to the first category and not mention ICT. Common responses were: food technology, textiles, graphics, product design, resistant materials, metal work, woodwork. Some students simply mention DT, and others include Art in their list. Engineering is mentioned a number of times, mainly clustered in two schools. Another school appears to offer a course in electrics/electronics. Other lessons mentioned were materials or plastics, and mechanics

Section 7: The case study data

Transcription of the interviews from the baseline case study data has just been completed. The analysis will be presented in the second project report.

Appendix 6 provides an overview of the chief characteristics of the case study schools.

Section 8: Conclusions

This report covers the first phase of data collection for the project. One of the principal aims of the project is to explore how young people's responses to STEM subjects are influenced by Tim Peake's mission. This aspect can only be explored when the project has gathered its second set of data to compare with initial responses. The conclusions here are therefore the key points to emerge from the first data collection phase.

Interviews with key informants

The key informants are a highly select group of people as they all have key roles and interests in space science. The nature of the work mans they are very positive about human spaceflight and the *Principia* mission. The interviews with the key informants showed that they were involved in a wide range of activities related to the *Principia* mission, including lectures, working with schools, astronomy clubs, STEM clubs, careers conferences, the development of resources, and acting as consultants for media events linked to the mission.

Most key informants were positive about the potential of the *Principia* mission and Tim Peake's work to improve young people's attitudes to STEM subjects and to space. Space was seen as a very useful context in which knowledge and understanding of STEM subjects could be developed, and also a good means of promoting awareness of a range of careers in STEM. There were aspirations for space science to raise the quality of people employed in the space sector, and to serve as a way of attracting young people from traditionally-underrepresented backgrounds into STEM careers more generally. Views were also expressed about space science and the *Principia* mission encouraging young people to value the qualities of being brave and adventurous, and willing to try new things, and to become more aware of the need to take care of the Earth as a resource.

Some concern was expressed by the key informants about how engaged the school community as a whole was with the *Principia* mission.

Data from students

The student survey has revealed a number of interesting points about young people's attitudes to STEM subjects and to space science.

Overall, both primary and secondary students are positive about the value of STEM subjects, and about space. They believe science makes an important contribution to people's lives, and technology and engineering can also help improve things. Their views of the contribution of mathematics are less positive.

Students' confidence about their abilities in science and maths is about the same in the primary and secondary age ranges. They are less confident about their abilities in engineering, which was explored in the secondary school survey only. This may well be explained by their lack of confidence about what the subject entails, as none of them have dedicated engineering lessons at their age.

More secondary students than primary students believe they will need to use science, technology and, especially, maths in their jobs. Views about engineering are less clear-cut, which may, again, be to do with lack of knowledge.

There is a downward trend from primary to secondary age groups in relation to considering careers in STEM subjects, particularly for maths, with around half of secondary school students seeming already not considering careers involving those subjects. Views of careers involving technology are more positive.

Space science is viewed very positively and seen as making a worthwhile contribution to people's lives, with the majority of both primary and secondary age students believing that space science makes lives on Earth better. There was also support for sending people into space to find out more about the universe, and that this activity was worth the money spent on it.

Whilst the National Curriculum for England does not have a requirement for teaching about space, some teachers bring space-related activity into their lessons. Students in some schools were already aware of Tim Peake and his mission at the time of the baseline survey. Students were able to report on a range of space-related matters they had learned about in the last year.

There is a belief that you need to be clever to do a job in space science or technology, more so than the need to be clever to do maths and science.

Space is a topic of significant interest to students, both in school and outside school. The positive attitudes are particularly pronounced in the primary age group.

Primary students believe more strongly than secondary students that they have the ability to attain a job in space science.

Students are very positive about the possibility of them travelling to space, though less interested in careers involving space science. Boys are particular positive about travelling to space, with the divide between boys and girls more pronounced in the secondary age group.

Some confusion about STEM-related clubs in schools emerged, with students from the same class reporting that there was or was not a particular club in their school. This confusion was particularly apparent in secondary schools, and appears to be linked to the use of the word 'club' for remedial or additional support classes. Where STEM-related clubs did exist in the form of an 'extra' for interested students, they covered a variety of topics including environmental matters, health matters, additional practical activities to those undertaken in lessons, computer programing and space/astronomy clubs.

Primary age students are much more positive about participation their schools' STEM-related clubs, with enthusiasm being highest for space/astronomy clubs.

In summary, the baseline data points to students being positive about space, particularly at the primary level. The second phase of data collection will seek to explore any changes in patterns of responses.

Section 9: Next steps

The main thrust of the project in the next few months will be to undertake the data collection for the second phase of the project, the post launch data. This will be completed before Tim Peake returns from the International Space Station. At the moment, this return is planned for early June 2016.

The data from Phase 1 will undergo further analysis, which involves the following:

1. Teacher interview transcripts will be sent to the interviewees for then to verify the contents and check for factual accuracy.
2. Teacher interview data will be analysed to identify themes for further investigation, highlighting important pieces of evidence along the way.
3. Student focus group data will be analysed.
4. The qualitative data from the survey will be subjected to closer scrutiny in order to identify aspects of particular interest to pursue in Phase 2. There are also subsections of the survey, such as out-of-school learning, and various socio-economic aspects, which warrant closer scrutiny.

The map of resources will continue to be regularly updated.

A further application will be made to the National Pupil Database to obtain individual attainment and socio-economic data for the students who were interviewed in the case study school focus groups, and who will be followed specifically for the duration of the project.

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Appendix 1: The key informant interview schedule

(Telephone) interview with key informant

Thank you very much for agreeing to talk to me about your views regarding (human) spaceflight and the educational developments related to it. A team from the University of York led by Judith Bennett has been asked to provide an external evaluation of primary and secondary school students' attitudes to STEM subjects in response to developments around British human spaceflight. The team includes Jeremy Airey, Lynda Dunlop and Maria Turkenburg.

As part of the three-year evaluation we would like to draw on your views about the aims of spaceflight and related educational developments, and the extent to which these aspirations are met. The discussion will be confidential and the reporting will be anonymous, so I hope you can be as frank as possible. The interview questions are detailed below.

1. The context: your organisation and your role within it

I would like you to talk briefly about your organisation, relating to STEM.

a. Can you briefly summarise the remit of your organisation?
(funder, resource producer, education establishment, other)
b. What has traditionally been its role in the field of STEM education?
(Science, Technology, Engineering, Maths)
c. What are your specific responsibilities within the organisation? What significant previous STEM-related positions did you hold?

2. Your aspirations for Tim Peake's Principia Mission

I would like you to talk briefly about your personal aspirations for Tim Peake's mission.

a. What do you see as the aims of this mission?
b. What do you view as its benefits to STEM education? How about drawbacks?
c. What are your views of this mission in relation to young people in STEM education?
(opportunities for foreground for STEM subjects, cross-fertilisation between STEM subjects, increase engagement, increase awareness, other?)

3. Views on Project SPACE: STEM Pupils' Attitude Change Evaluation

The main objectives of our research project are:

- to establish whether or not there is a causal link between spaceflight and students' responses to STEM subjects
- to explore underlying explanations for any relationships or factors of interest that might emerge
- to develop a map of educational resources related to human spaceflight, in particular Tim Peake's Principia Mission

a. Which of these objectives (or possibly another) is most important in your view? Can you please elaborate why you consider this of such importance?
b. What would be appropriate criteria for success for achieving this objective?
c. If this objective were to be achieved could you give examples of how this would affect the activities of your organisation?
d. Could you comment on the importance of achieving the other two objectives in turn by discussing the most important aspects?

4. Your hopes for outcomes of Project RISES

I would like you to talk briefly about your personal hopes for what might emerge from our research.

a. What do you see as opportunities? What about hurdles?
b. Do you have anything to add to the map of resources we are building? Can you point us to anything we must not overlook?

5. Any other comments

Do you want to comment on any other aspect of your expectations of the Project SPACE research or other related factors? Do you feel there is somebody else who it would be very useful for us to speak to about this research?

Thank you very much for taking the time to talk with me

Appendix 2: The on-line survey for primary level students

Appendix 3: The on-line survey for secondary level students

Appendix 4: The baseline student interview schedule

RISES: Research Into Spaceflight and Engagement with STEM

Introduction:

My name is <add researcher's name>, and I am here to talk to you about learning about space and how you feel about that. I have a few questions I would like to ask you and I'd like us to chat about it together. There are no right or wrong answers; I just want to know what you think. I'm going to record the session so I don't forget what you've said, but it's only going to be used for the research project and nobody in your school will know what you've said. We won't use your real names or your school's real name when we write up our report.

1. What can you tell me about what you have learnt about space in the last year?

Probes:

Was it in a particular lesson of science? Technology? Engineering? Mathematics? 'Topic'?
[Adapted for KS2/KS3 accordingly]

Do you like learning about space in these subjects? Why? Do you think it is important to learn about space?

Do you think you have learnt more or less about space this year than last year? Can you think why? Have you heard about Tim Peake? Mission X? The Rocket Science project? Are you taking part?

[If they start talking about a specific space-related lesson they remember, use additional probes: Why do you remember this lesson? When was it? What did you learn in this lesson? Which teacher was teaching you?

2. Can you talk to me about what you have learnt about space outside school?

Probes:

Why do you remember it? When was it?

Where were you? Who was with you?

3. In the questionnaire we have already asked you whether you like science, maths, technology and engineering [adapted for KS2/KS3 accordingly]. We also asked you whether you think these subjects are important. Sometimes, people say they think they are important, but they do not necessarily like them. Can you talk to me about why you think these things do not always match up?

4. In the questionnaire we also asked you whether you think you are going to use these subjects in your job. Can you talk to me about whether you think you would study them, at school or later, whether or not you would have to do so?

5. One of your classmates said [pertinent issue(s) from questionnaire - tailor to school and group] in the questionnaire. Can you talk to me about why this may be important?

Probes:

Is it more important to some people than others? Why?
How do you think this came about in your school?

Appendix 5: The baseline teacher interview schedule

RISES: Research into Spaceflight and Engagement with STEM

Semi-structured interview with in-service teacher(s) who may or may not be involved with education projects directly related to Tim Peake's mission. They will be (one of) the teacher(s) of the students who complete our questionnaire.

Introduction about aims of project

Thank you very much for agreeing to talk to me about your views and experiences regarding the teaching and learning about space and (human) spaceflight in your school. A team from the University of York led by Prof Judith Bennett has been asked to provide an external evaluation of primary and secondary school students' attitudes to STEM subjects in response to developments around British human spaceflight. I am {insert name of researcher}, and one of the researchers on the team. Our discussion will be confidential and the reporting will be anonymous, so I hope you can be as frank as possible. The interview questions are detailed below.

1. DEFINITION

I would like you to talk briefly about how you view the main concepts of the questionnaire your students completed.

a. How would you define 'engagement with STEM'?
b. How about 'attitudes to STEM'?

2. PERSONAL AND TEACHING EXPERIENCE

It is thought a teacher's own experience and interest, on top of their approach to teaching about STEM, may have an influence on their students' attitudes. I would like you to talk briefly about your views of STEM and space.

a. Primary: To what extent are you comfortable with teaching and learning about STEM?
Secondary: To what extent are you comfortable with the curriculum teaching of your STEM subject, specifically in the context of STEM in the workplace and STEM in everyday life? [*Adapted to the teacher's subject specialism where known*]

Probes [*only use 2nd and 3rd if time*]:

- What is your own educational background, more specifically your highest STEM qualification, and perhaps even more specifically your highest qualification in which you learnt about space? [*Science capital's "What you know"*]
- What kind of activities do you personally engage in which you would regard to be related to STEM? [*Science capital's "What you do"*]
- Can you talk about family and friends who may have influenced your views of STEM? [*Science capital's "Who you know"*]

b. What do you think is important for students to learn regarding STEM and space, and how do you approach teaching these things?

3. ROLE OF EDUCATION

I would like you to talk briefly about the role of education and schools in developing students' engagement with STEM. The context is the premise that in the future we need more people, and people from more diverse backgrounds, with STEM qualifications.

a. What do you think is the role of education in raising interest in and/or improving attitudes to STEM?

Alternative wording: How might education be employed to achieve increased engagement in STEM, in your opinion?

4. ROLE OF SPACEFLIGHT

I would like you to talk briefly about the role space and (human) spaceflight might have in influencing students' engagement with STEM.

a. What, if anything, do you think is the influence of space/spaceflight/human spaceflight on students' views of STEM?
b. How do you view the potential of using space/spaceflight/human spaceflight in the teaching and learning of other STEM-related topics? [*Especially at secondary schools this question could/should be tailored to the subject the interviewee teaches*]

5. SCHOOL INVOLVEMENT

I would like you to talk briefly about the teaching and learning about STEM and space that goes on in your school, especially the current academic year.

a. What, if anything, is happening in your school to raise students' interest in and/or improve students' attitudes to STEM?
b. What, if anything, is happening in your school regarding the teaching and learning about space and (human) spaceflight? [*Assuming they talk readily about the space topic(s) in the National Curriculum, probe about specific Tim Peake-related projects such as Rocket Science, Mission-X, Destination Space, Astro Pi, I'm an Astronaut…, Team Tim etc*]

6. STEM CLUBS

I would like you to talk briefly about any out of school club activity related to STEM that you or your colleagues engage in.

a. Does your school have STEM club, or individual STEM subject club(s)?
b. Can you give an example of activities that take place at each of these clubs? [*This question in particular may be one to send to potential interviewees in advance*]

Then a final question:

Is there anything you had hoped to say but have not had a chance to yet?

Appendix 6: The case study schools

School	Primary/ Secondary	State/ Independent	Type of Establishment	N° on roll[i]	Urban/Rural description[ii]	IDACI[iii]	% FSM[iv]	% not WBRI[v]	Teacher participant(s)	Student participants
PA	P	S	Academy Converter	270	Urban>10k less sparse	0.273	30.7	7.4	1. Year 5 teacher	6 Year 5 students,
PB	P	S	Community School	324	Urban>10k less sparse	0.035	2.5	15.1	1. Science coordinator/Year 5 teacher 2. PE & ICT coordinator/Year 5 teacher	6 Year 5 students,
PC	P	S	Community School	478	Urban>10k less sparse	0.489	11.6	89.3	1. Year 5 teacher	6 Year 5 students,
PD	P	S	Voluntary Controlled School	77	Village - less sparse	0.069	2.6	0.0	1. Science coordinator 2. Year 5 teacher and Deputy Headteacher	10 Year 5 students, 5 boys, 5 girls
PE	P	S	Voluntary Aided School	333	Urban>10k less sparse	0.344	22.5	67.8	1. Maths coordinator/Year 5 teacher 2. Art and English coordinator/Year 5 teacher	8 Year 5 students,
PF	P	S	Voluntary Aided School	111	Village - less sparse	0.020	2.7	9.8	1. ICT coordinator	6 Year 5 students, 3 boys, 3 girls
PG	P	I	Other Independent School	1091	Urban>10k less sparse	N/A	NK	NK	1. Science coordinator/science teacher 2. Year 5 teacher	7 Year 5 students, 4 boys, 3 girls
PH	P	S	Community School	627	Urban>10k less sparse	0.656	22.6	98.3	1. Learning mentor with 'Space' as special remit	6 Year 5 students, 3 boys, 3 girls
PI	P	S	Academy Converter	625	Urban>10k less sparse	0.076	2.7	23.1	1. Science coordinator/Year 5 teacher 2. Art and DT coordinator/Year 5 teacher 3. Former science coordinator and Deputy Headteacher	6 Year 5 students, 3 boys, 3 girls
SA	S	S	Community School	322	Urban>10k less sparse	0.258	25.8	33.5	1. Head of Science and related Faculty 2. Head of DT	7 Year 8 students, 4 boys, 3 girls

									3. Technology Technician	
SB	S	S	Community School	885	Urban>10k less sparse	0.174	17.4	86.1	1. STEAM coordinator/Science teacher and Assistant Headteacher 2. DT teacher	5 Year 8 students, 2 boys, 3 girls
SC	S	S	Controlled School	677[vi]	Town	NK	13[vii]	NK	1. Science teacher 2. Technology teacher	6 Year 8-equivalent students, 3 boys, 3 girls
SD	S	I	Other Independent School	1038	Urban>10k less sparse	N/A	NK	NK	1. Head of Physics 2. Maths teacher (second in command)	8 Year 8 students, 5 boys, 3 girls
SE	S	S	Community School	587	Village - sparse	0.051	5.1	3.6	1. Science teacher 2. Maths teacher	6 Year 8 students, 4 boys, 2 girls
SF	S	S	Academy Converter	1256	Urban>10k less sparse	0.084	8.4	13.4	1. DT teacher and Deputy Headteacher 2. Science teacher	6 Year 8 students, 3 boys, 3 girls
SG	S	S	Voluntary Aided School	1406	Urban>10k less sparse	0.022	2.2	13.6	1. Head of Science 2. Engineering teacher	6 Year 8 students, 3 boys, 3 girls
SH	S	S	Community School	401	Urban>10k less sparse	0.167	16.7	6.7	1. STEM coordinator/Maths teacher 2. Science teacher	7 Year 8 students,

[i] N^{o} on roll = 'Head count pupils' data from National Pupil Database 2014.
[ii] Urban/rural description = categorisation of local area, data from National Pupil Database 2014.
[iii] IDACI = Index of Deprivation based on postcode of the local Super Output Area (from http://www.education.gov.uk/cgi-bin/inyourarea/idaci.pl?postcode=); these data are only available for England, and are not suitable criteria for independent schools. The index runs 0-1, with 1 representing highest level of deprivation.
[iv] % FSM = percentage take-up of Free School Meals out of the total school population (from National Pupil Database 2014); these data are not known for independent schools.
[v] % not WBRI = crude ethnicity measure, (100-% WBRI), with % WBRI being percentage of students declared White British in the National Pupil Database 2014. These data are not known for independent schools, and for schools outside the remit of the National Pupil Database.
[vi] Data from 2009 inspection report.
[vii] By comparison with towns included in National Pupil Database.