

Evaluation of the

National Schools Observatory

Final Report

**Centre for Science Education and the
Centre for Education and Inclusion
Research**

at Sheffield Hallam University

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Table of Contents

Executive Summary	2
1 Introduction	3
2 Methods.....	3
2.1 Methodology	3
2.2 Methods	4
3 Programme logic model	5
4 Pupil responses	6
5 Teacher responses	13
6 School case studies	23
6.1 Case studies.....	23
6.2 Cross-case commentary	29
7 Achieving the intended outcomes; hypothesis conformation; reach and significance.....	31
7.1 Shorter-term outcomes.....	31
7.2 Longer-term outcomes.....	32
7.3 Programme hypotheses	33
7.4 Reach and significance	34
8 Recommendations and criteria for development.....	35
8.1 Recommendations	35
8.2 Criteria for future developments	36
9 Project team.....	38

Executive Summary

- This evaluation was carried out by the Centre for Science Education and the Centre for Education and Inclusion Research at Sheffield Hallam University.
- The main aim of the evaluation focussed on how the NSO influences attitudes to STEM subjects
- To guide the evaluation a programme logic model was developed, along with a set of programme hypotheses that described the rationale behind the intervention design
- A 'pre- and post-use, with comparator/control groups' model was not possible due to the post-involvement timing of the evaluation
- A mixture of questionnaires and school visits were used to gather data. Questionnaires were developed for primary pupils, pupils aged 11-14, pupils aged 14-16 and post 16 students. A separate teacher questionnaire was also used. Response rates for some of the questionnaires were too low to do a meaningful analysis, however, sufficient were obtained from 14-16 pupils, and teachers, to process into this report. The online service *Survey Monkey* was used.
- The pupil survey was completed by a group of young people who were more disposed to science than a more randomly selected group (based on comparisons with other surveys)
- Pupil responses were highly positive about the impact of the NSO on their attitudes to science and their awareness of how scientists and astronomers worked
- Teacher responses were also highly positive, and echoed the pupil responses regarding impact on enthusiasm and awareness of the work of scientists
- Most teachers were physics graduates, and counting subsidiary subjects studies at university, around one third had studied astronomy
- Use of the NSO was made in a wide variety of contexts, including in class, in clubs, as an after school activity, with individual pupils, with groups and classes, linked to the curriculum, as a lesson support tool, to support teacher professional development
- The Case Study visits to six schools were also highly positive. Teachers made use of the NSO independently of any school STEM policy or programme
- A key use of the NSO is to support GCSE Astronomy
- Pupil awareness of STEM careers was increased through use of the NSO, in particular the breadth of jobs related to astronomy and space science
- We found evidence of achievement of all the shorter term aims of the project
- We found evidence that led us to suggest that the longer-term aims of the project (such as progression on to STEM subjects and careers) which were not possible to measure during the evaluation, were likely to be met
- The programme hypotheses were supported by the evidence from the evaluation
- We found the reach and significance of the NSO to be considerable. In our view, this initiative has unprecedented reach, and is one of the most significant educational initiatives in the STEM field linked to an HEI
- We provide a series of recommendations and criteria for future development, covering user engagement, curriculum coverage, curriculum resources and activities, marketing and communications, training and web site functionality
- A key recommendation is to establish a lead user group to guide future developments and provide a test-bed for new activities and resources.

1 Introduction

The National Schools' Observatory (NSO) is a unique resource, allowing schools in the UK and Ireland to make their own observations using the Liverpool Telescope. As part of this offer, it provides teachers and pupils with access to projects, activities (supporting science, maths, ICT), as well as support for GCSE Astronomy. It is a significant resource in the push to make STEM subjects more engaging for young people. In England, there has been a national STEM programme (funded in part by DfE and BIS), which has focussed on raising participation rates in post-16 STEM subjects, particularly the physical sciences, mathematics and engineering. Similar programmes have occurred in the other UK nations and Ireland. These STEM programmes have taken place alongside other national strategies to raise attainment, but the common factor across the push for more STEM skills (as opposed raising STEM attainment) has been the focus on changing young people's attitudes to the subjects, and careers in related fields.

2 Methods

2.1 Methodology

The key aims of the NSO is:

- Using astronomy to promote a greater appreciation of STEM subjects, particularly among school students/pupils.

In addition, a series of further aims are:

- Supporting UK and Irish science education
- Raising awareness of LJMU scholarship
- Raising awareness of UK expertise in astronomy and physics

The evaluation brief focussed the team on how the NSO influences attitudes to STEM subjects, and it also provided the following evaluation aims:

- Provide evidence of impact for external bodies and funders (including use in the REF submission).
- Provide evidence of the strengths and weaknesses of the NSO to inform priorities for future development.
- Provide a framework of criteria against which developments in the future can be assessed.

In getting a fuller picture of what the NSO was about, we constructed a Programme Logic Model (see below), which extrapolated a series of intended outcomes onto the framework of aims outlined above. These were:

Shorter-term outcomes

- Increased interest in science (STEM)
- Increased awareness of the applications of science
- Increased awareness of STEM careers

- More informed and enthused Astronomy students
- More engaged teachers
- Increased teacher knowledge and confidence

Longer-term outcomes

- Increased positive attitudes to STEM subjects and careers
- Greater attainment in STEM subjects, and uptake and attainment in GCSE Astronomy
- Higher level of teacher skill in dealing with Astronomy

The methods used were primarily targeted at gaining evidence for the achievement of the above outcomes. We could use this evidence to determine the degree to which the NSO influences attitudes to STEM subjects, the focus provided for us by the NSO team. In addition, by adopting a *realist* methodology, we developed a series of programme hypotheses, which attempted to set out the theory or logic of why the activities might be linked to the outcomes. The programme hypotheses were:

- In and out-of-school engagement with the NSO helps to maintain students' interest in science/STEM subjects as they get older
- Student skills/confidence will develop through taking part in NSO activities
- Student attitudes to science will become more positive as a result of engaging with NSO activities
- Students' broad awareness of STEM careers will increase through direct contact with STEM professionals
- Multi-node interventions have more sustained impact than single node ones
- Teacher knowledge and confidence increases through working in a purposeful way with NSO activities

2.2 Methods

A mixture of questionnaires and school visits were used to gather data. Questionnaires were developed for primary pupils, pupils aged 11-14, pupils aged 14-16 and post 16 students. A separate teacher questionnaire was also used. The NSO database of teacher contacts was used to inform schools of the evaluation, including links to the questionnaires, which were put on *Survey Monkey*. Response rates for some of the questionnaires were too low to do a meaningful analysis, however, sufficient were obtained from 14-16 pupils, and teachers, to process into this report.

The NSO were asked to supply a list of schools that the evaluation team could visit. From this list, six were selected, covering the North of England (4 schools), the South East of England (1 school), and Wales (1 school). In each school, the teacher responsible for NSO engagement was interviewed, and a group of pupils, either 11-14 or Post 16 (3 of each type) were also engaged in a led-discussion. In compiling the Case Studies, data about the school (eg DfE and Ofsted websites for English schools).

Numbers of questionnaire responses:

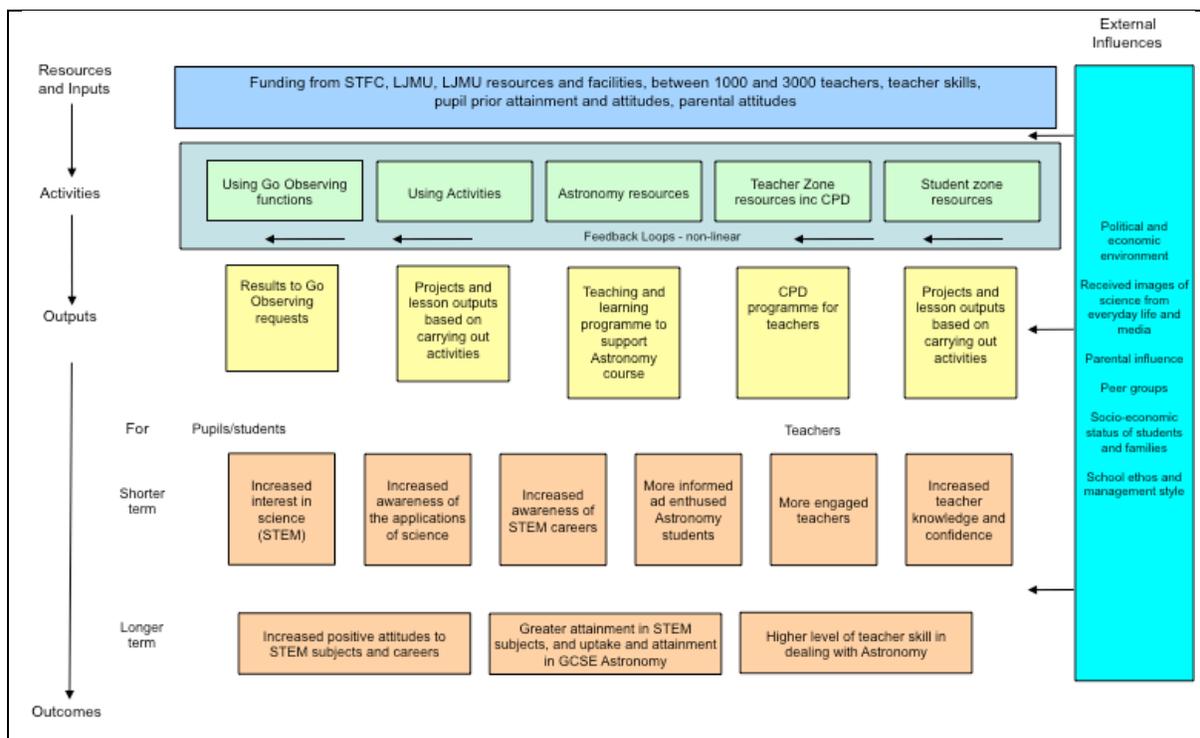
Primary pupils	10
11-14 aged pupils	20
14-16 aged pupils	76
Post 16 students	28
Teachers	127

3 Programme logic model

A programme logic model provides a useful tool to analyse and categorise the components of an educational intervention project. It separates out the resources and inputs, the project activities, the project outputs, and the short and long-term outcomes. In creating the model the result is a linear diagram (see below), which does not reflect the true complexity of educational interventions and their contexts, but which allows an initial subdivision of project elements that aids evaluation planning and analysis. The inherent complexity is addressed through identifying feedback loops, promoters and inhibitors of activity and impact (including school context issues and external environment influences), and addressing these in the analysis.

We also adopted a series of hypotheses, to explain what happens in an intervention such as the NSO. These were:

- In and out-of-school engagement with the NSO helps to maintain students' interest in science/STEM subjects as they get older
- Student skills/confidence will develop through taking part in NSO activities
- Student attitudes to science will become more positive as a result of engaging with NSO activities
- Students' broad awareness of STEM careers will increase through direct contact with STEM professionals
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- Teacher knowledge and confidence increases through working in a purposeful way with NSO activities



4 Pupil responses

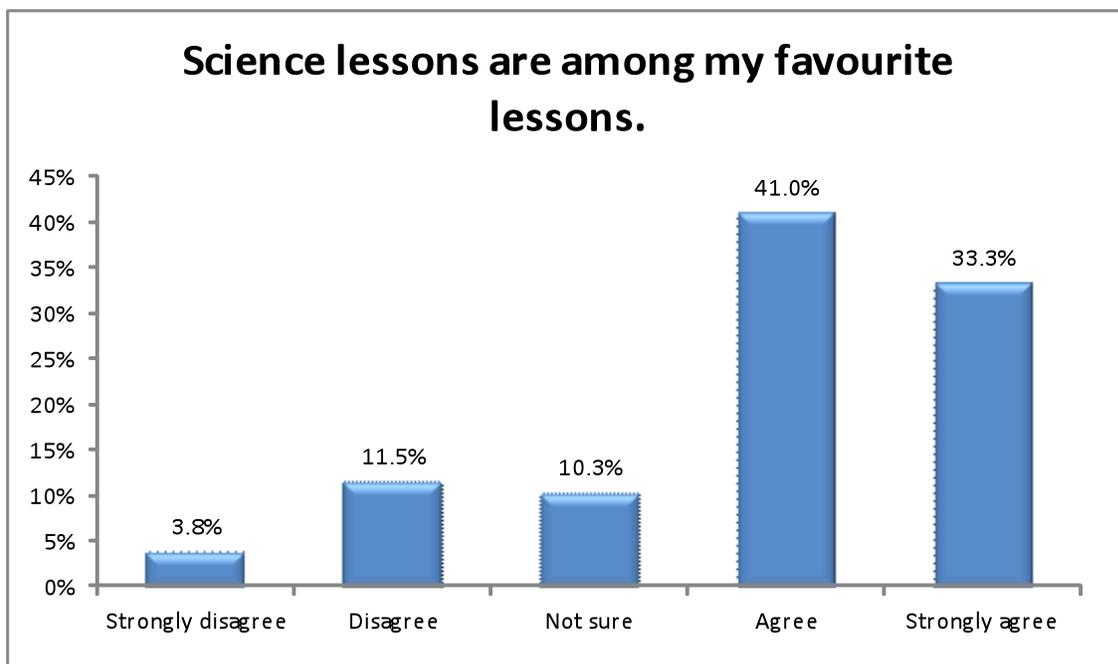
General pupil characteristics and attitudes to STEM subjects

Pupils were spread across the 14-16 age range, with 41% aged 15, 37% 16 and 22% 14. A slight majority of pupils were female (56%).

The pupils were generally positive about science. 74% agreed or strongly agreed that science lessons were amongst their favourite lessons, with 33% strongly agreeing. 15% disagreed or strongly disagreed. (See Figure 1). These figures show a higher affinity for science than other surveys we have carried out into pupil subject preference, and show that the cohort of pupils responding to the survey are more positively disposed to science than a randomly selected group of pupils.

For instance, the results for the same question used in the pre-event pupil survey for the Big Bang 2010 evaluation (Mannion et al, 2010), for non-participant pupils in Y10 and 11 (ie ones who were not attending the event) were 32.5% (Y10) and 41% (Y11), answering strongly agree, or agree.

Figure 1



The pupils were also generally positive about mathematics, although to a lesser degree compared with science. 70% agreed or strongly agreed that maths lessons were amongst their favourite lessons, with 29% strongly agreeing. 22% disagreed or strongly disagreed.

Turning to out of school activities and attitudes to science, 56% of pupils agreed or strongly agreed that they like watching science programmes with 11% disagreeing or strongly disagreeing. This compares with around 30% of Y10 pupils agreeing or strongly agreeing with this statement, in the Big Bang evaluation quoted above.

76% of pupils agreed or strongly agreed that science has a positive influence on society (54% of Y10 in Big Bang evaluation), with just 6% disagreeing or strongly disagreeing.

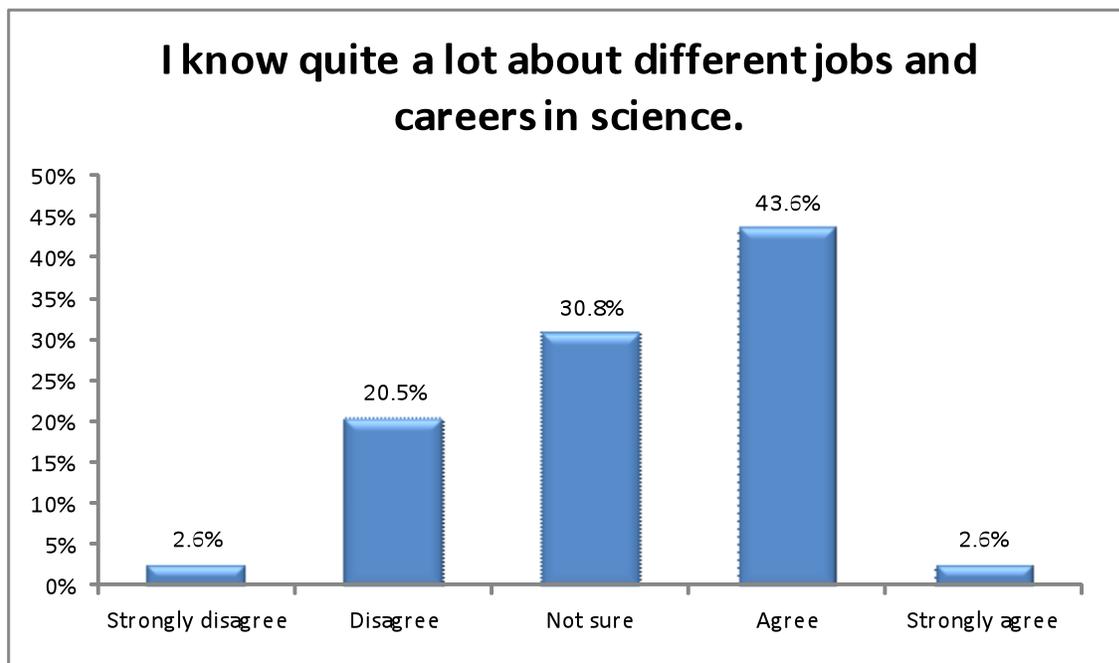
Half of pupils agreed or strongly agreed that people who do not know much about science are at a disadvantage in today's society, but 23% disagreed or strongly disagreed, and 27% were not sure.

These results and comparisons indicate (and are backed up by the Case Studies) that pupils engaged with the NSO are more positive in their attitudes to science than a more randomly selected group.

Career plans

Turning to career planning, 46% agreed or strongly agreed with the statement 'I know quite a lot about different jobs and careers in science.' 31% were not sure, and 23% disagreed or strongly disagreed. See Figure 2.

Figure 2



The evaluation team includes staff that worked on the DfE's STEM Subject Choice and Careers programme (2008-11), and a range of other projects promoting STEM subjects to young people. The figures for pupil awareness of jobs in science matches the levels of awareness other surveys have shown, (Mannion et al. 2011, *Engineering Science, A Report for the Esmée Fairbairn Foundation*).

47% agreed or strongly agreed that they were considering a job or career in science. 26% were not sure, and 27% disagreed or strongly disagreed.

45% agreed or strongly agreed with the statement 'I know quite a lot about different jobs and careers in maths.' 24% were not sure, and 31% disagreed or strongly disagreed. This is slightly higher awareness for mathematics than for science, which we have not encountered in other surveys. [REF]

28% agreed or strongly agreed that they were considering a job or career in maths. 26% were not sure, but 46% disagreed or strongly disagreed.

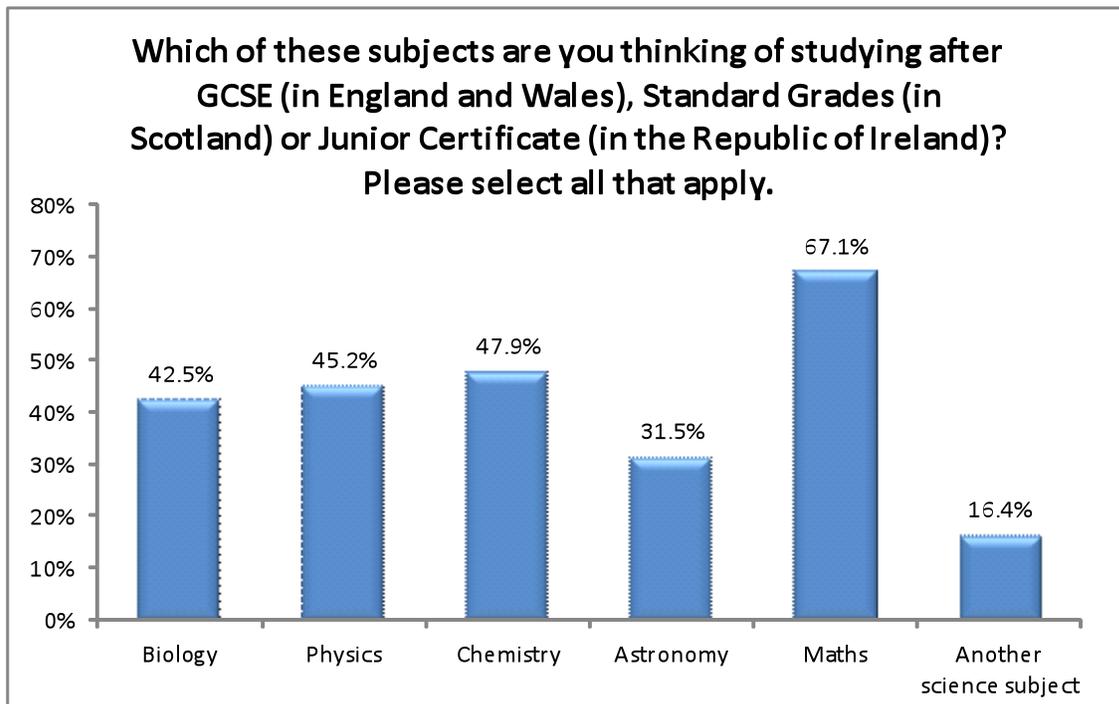
As for the responses about general disposition to science, these results indicate a higher level of awareness and future intent towards STEM subjects than a more randomly selected group of pupils of this age.

Planning for further study

About two thirds of pupils agreed they would choose at least one science subject at post-GCSE (or equivalent) stage, with 45% strongly agreeing with this. 16% disagreed or strongly disagreed, with 17% not sure.

About 65% of pupils agreed they would choose mathematics at post-GCSE (or equivalent) stage, with 41% strongly agreeing with this. 23% disagreed or strongly disagreed, with 13% not sure. Two thirds of pupils were considering studying maths after GCSE or equivalent, with between 43 and 48% considering Biology, Physics and Chemistry. 32% were considering Astronomy, and 16% another science subject. See Figure 3.

Figure 3



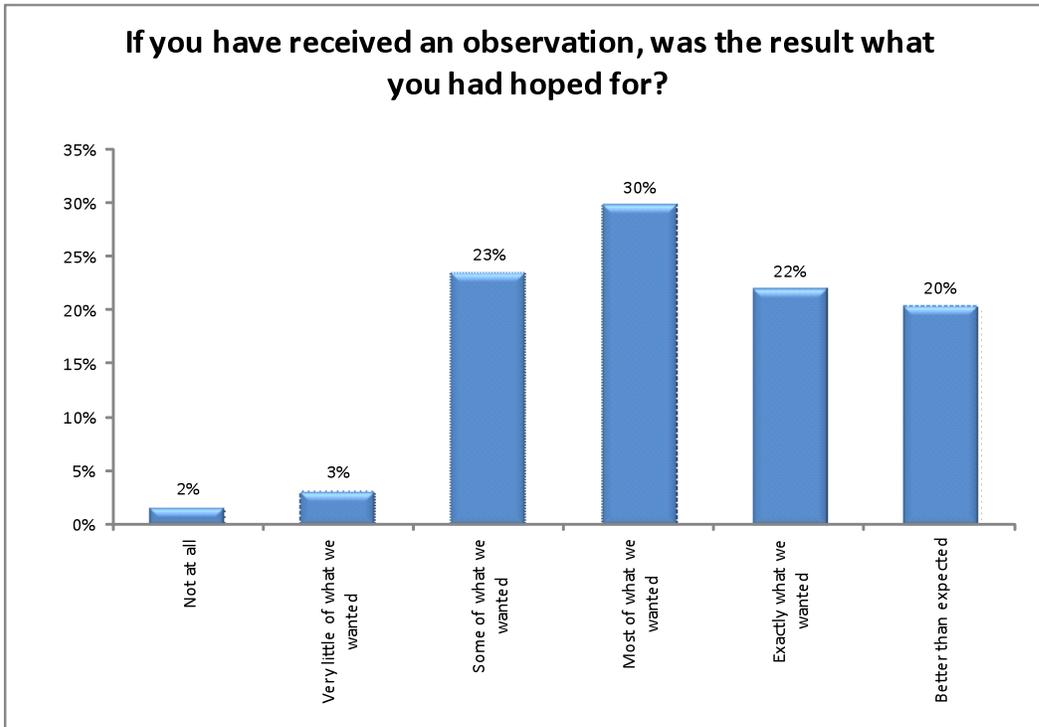
Again, the positive figures for science subjects (and mathematics) are higher than data obtained in more random samples. The figure for Astronomy (32%) perhaps reflect the largely self-selecting group who use the NSO, but also indicate the positive impact of the NSO on motivating young people towards astronomy as a subject.

Use of the NSO

Turning to use made of the NSO, 73% of pupils had used the NSO in a lesson, 30% for a project, 14% in a club and 18% for something else, most commonly coursework or controlled assessment.

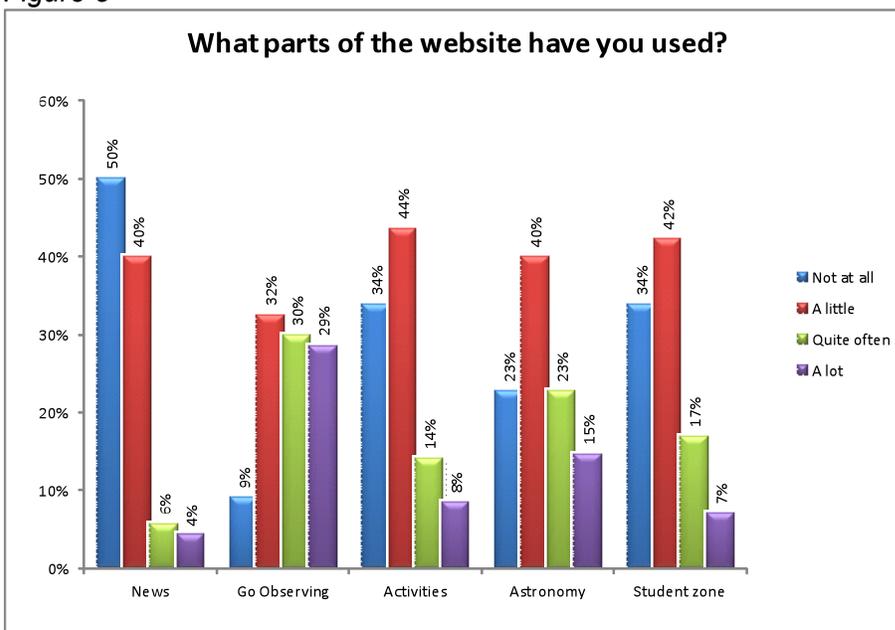
77% of pupils had asked for an NSO telescope observation. Of these, 44% got exactly what they wanted or more than what they expected, 30% got most of what they wanted, 23% got some of what they wanted and only 5% got very little or nothing. See Figure 4

Figure 4



By far the most commonly used aspect of the NSO website was Go Observing, used a lot by 29% of pupils. The Astronomy section was also used commonly, with 15% using it a lot. News was least well used, with 50% not using this at all, followed by Activities and Student Zone, each of which was not used at all by 34% of pupils. See Figure 5.

Figure 5



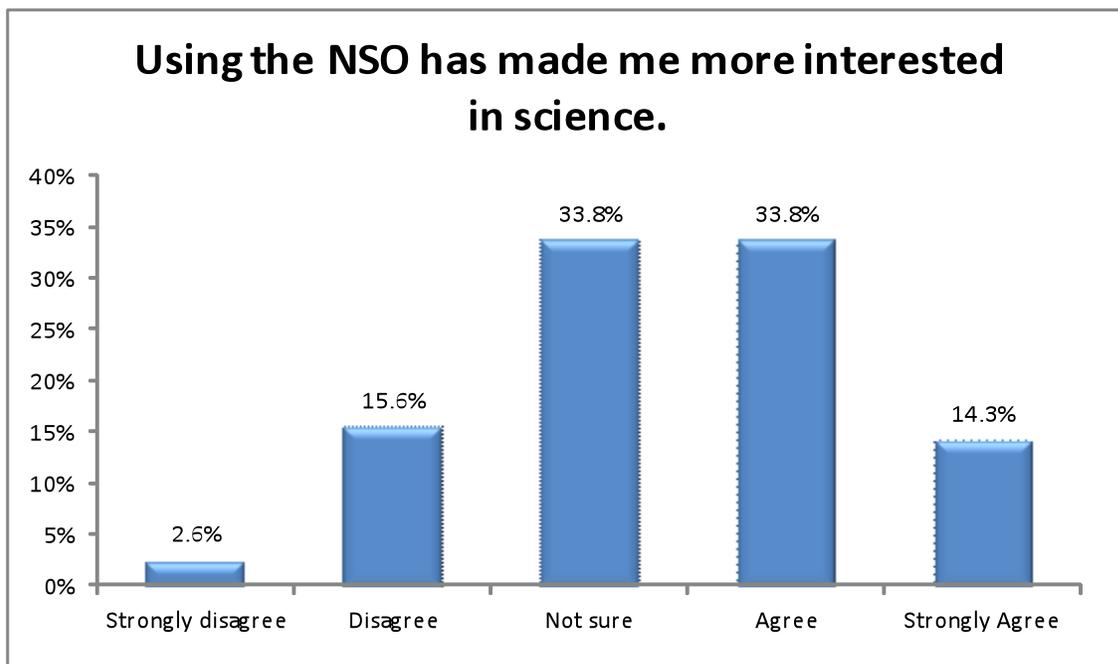
Pupils had tended to use the NSO recently, with 68% having used it in the last 3 months. About three quarters of pupils had used the NSO more than once with 40% having used it more than 5 times.

This indicates that for a large proportion of pupils engagement with the NSO is not a one-off occurrence, and therefore shows the characteristics of a multi-node intervention, rather than a one-off event. Other work done by the evaluation team indicates that multi-node interventions have more lasting impact on pupil attitudes to science (Mannion et al, 2011).

Impacts of the NSO

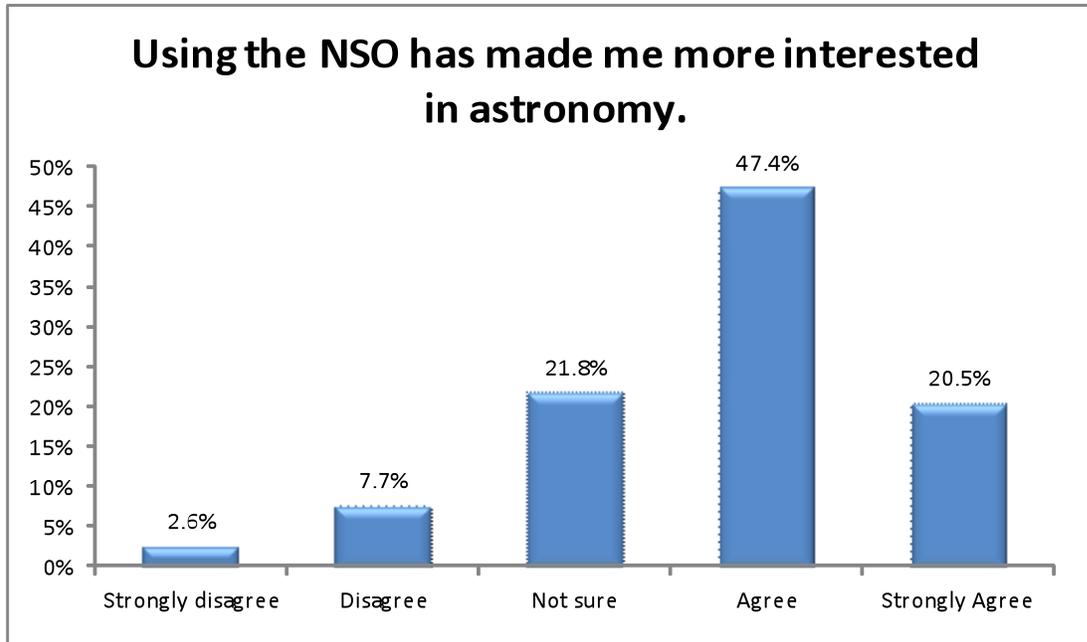
Turning to the impacts of using the NSO, 48% agreed or strongly agreed with the statement 'Using the NSO has made me more interested in science', with 14% strongly agreeing. 34% were unsure, and 18% disagreed or strongly disagreed. Given the initial positive disposition to science of many of the respondents, the figures for agreed or strongly agreed should be seen as highly positive, as they indicate a motivating impact even on the well-motivated (it could be argued). See Figure 6

Figure 6



68% agreed or strongly agreed with the statement 'Using the NSO has made me more interested in astronomy', with 21% strongly agreeing. 22% were unsure, and 10% disagreed or strongly disagreed. Again, the impact on interest in Astronomy is highly positive. See Figure 7.

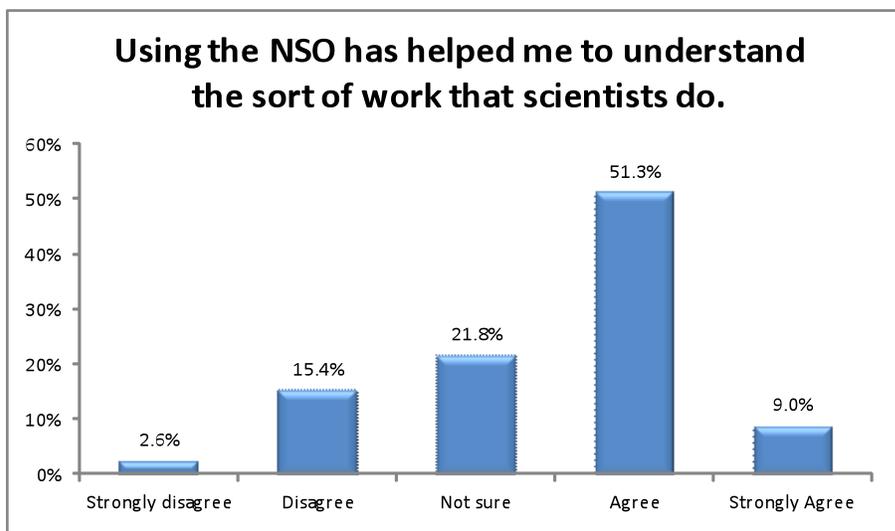
Figure 7



In contrast with astronomy and science, 13% agreed or strongly agreed with the statement 'Using the NSO has made me more interested in maths'. 26% were unsure, but the majority (61%) disagreed (47%) or strongly disagreed (14%). Other data from the Case Studies indicates that in some schools, the use of mathematics in connection with NSO activities was limited.

60% agreed or strongly agreed with the statement 'Using the NSO has helped me to understand the sort of work that scientists do', with 9% strongly agreeing. 22% were unsure, and 18% disagreed or strongly disagreed. This indicates the NSO's potential for addressing a key issue in STEM Careers education, which is the awareness raised about STEM careers through careers and enrichment and enhancement activity, rather than through more overt 'careers' activities. See Figure 8.

Figure 8



38% agreed or strongly agreed with the statement ' Using the NSO has made me more likely to think of a career in science', with 12% strongly agreeing. 33% were unsure, and 28% disagreed or strongly disagreed.

Improvements to the NSO

50 pupils answered the open question 'How could we improve the NSO?'. The largest group of responses focussed on observations. A number asked for improvements in return time, or in choice of observations. A selection is included here, verbatim.

Get more observations done, I got only 1/12 back which was a shame as I had to do completely different astronomy coursework project because of it.

Try and get observations to be completed more quickly, and try to complete all observations that are requested - many of my classmates did not receive many observations that they had requested, and many observations took a long time to be completed. Would it be possible to prioritise GCSE students' requests?

-Introduce a way of viewing the observations with a more common computer software than LTImage - I don't think that any of my classmates had LTImage at home, so it would be helpful if we had another way of viewing the images at home.

When observing the moon, give a larger selection area so you can observe an entire lunar feature

If there were a way to increase the amount of jobs that are done per night, so that we could get quicker returns, then this would be brilliant. It would also be great if we could actually see what the telescope was doing - by improving the webcam link to work at night, or by providing a real-time feed of what the telescope is looking at and various parameters about the telescope.

Others focussed on suggestions for improving the website:

*Add a gallery for the best photos taken and have some space games as well. :)
you could extend the website into different activities. you could also do it like Sam Learning and do tests, revision to help GCSE and other people get to grips with science and maths*

Possibly having a section to say 'Help find an exo planet' or get people involved in scientific research. I would like to know earlier if my observation will not be able to be taken instead of finding out very late.

Have guides that give recommendations for choosing filters and exposure times.

An email notification- receive an email when your observation has come back,

It could be easier to search the archives of photos on the database, all these photos are stunning, inspiring and amazing but it can sometimes be hard for people to find them and understand what they are.

Finally, a number of comments suggested they were happy with the NSO:

nothing needs improving

It is already very good

There is nothing that can be done, it is a great website. A website can not make somebody's opinion change.

You can't its perfect! Good job!

5 Teacher responses

Just under two thirds of the sample (63.8) are men, although it is unclear to what extent this is representative of the teachers involved in working with the NSO.

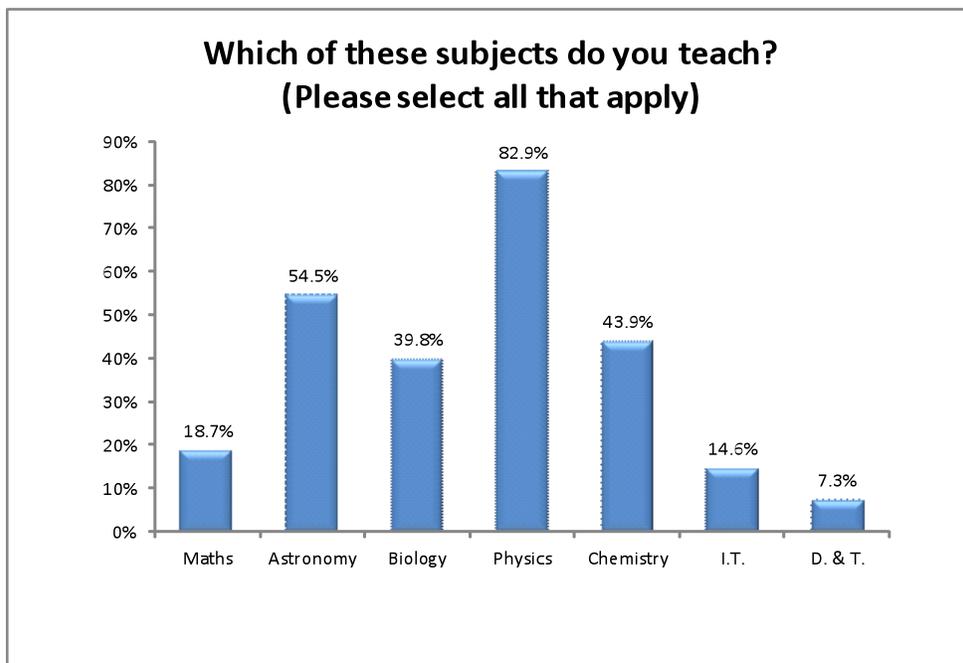
Years of experience

Years of experience	Frequency
0 to 5	26
6 to 10	16
11 to 15	27
16 to 20	14
21 to 25	20
26 to 30	10
31+	13

The mean number of years in teaching is 16 and the chart above indicates that there is a spread of experience, indicating the NSO is working with teachers throughout their careers.

The most frequently taught subject is Physics, taught by over 80% of the sample. 55% indicated they taught Astronomy as a discrete subject. About 40% taught Biology, and about 44% chemistry, with smaller proportions teaching D&T, IT and Mathematics. See Figure 9.

Figure 9



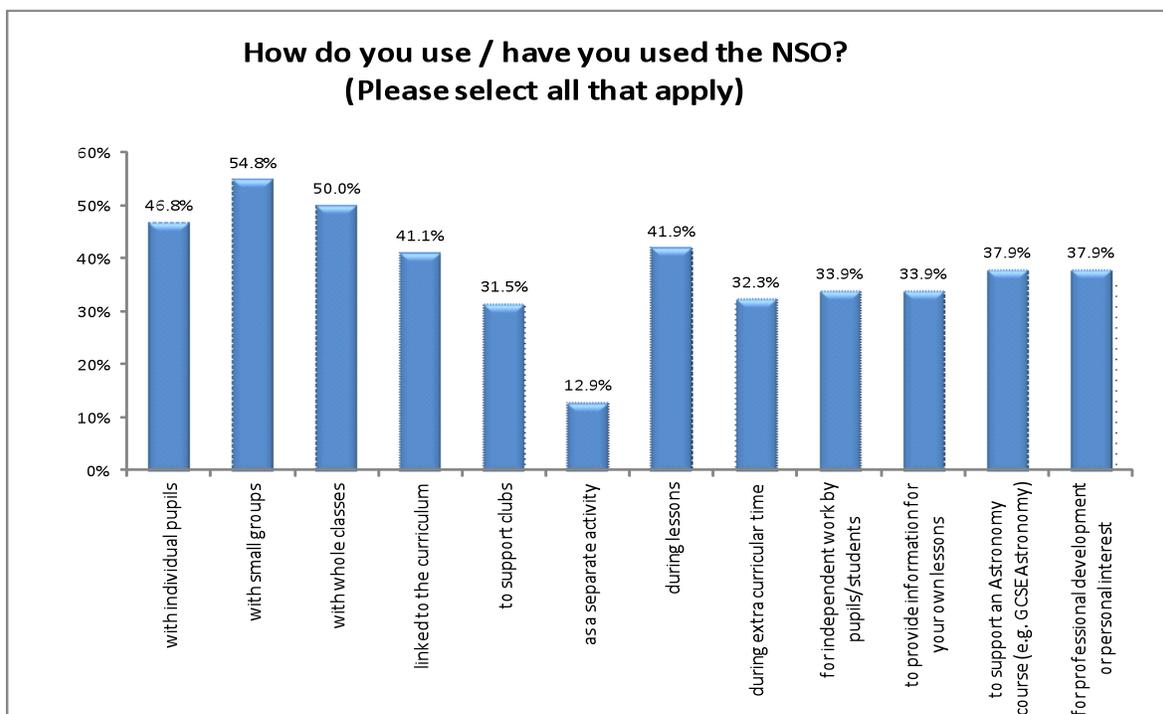
Using the NSO

The NSO is used in a wide variety of contexts, with significant numbers using almost all the suggested approaches. This indicates a highly flexible resource that suits classroom, club and individual use.

In relation to how schools organised their teaching using the NSO, small groups were most commonly used (55%) followed by whole class (50% and then individual pupils (47%).

In relation to curriculum linkages, the highest proportion linked it to the curriculum (41%) with about the same proportion linking it to lessons. Just under a third used the NSO work to support clubs or during extra-curricular time, with over a third using it to support independent pupil working. Only 13% treated the NSO as a separate activity. See Figure 10.

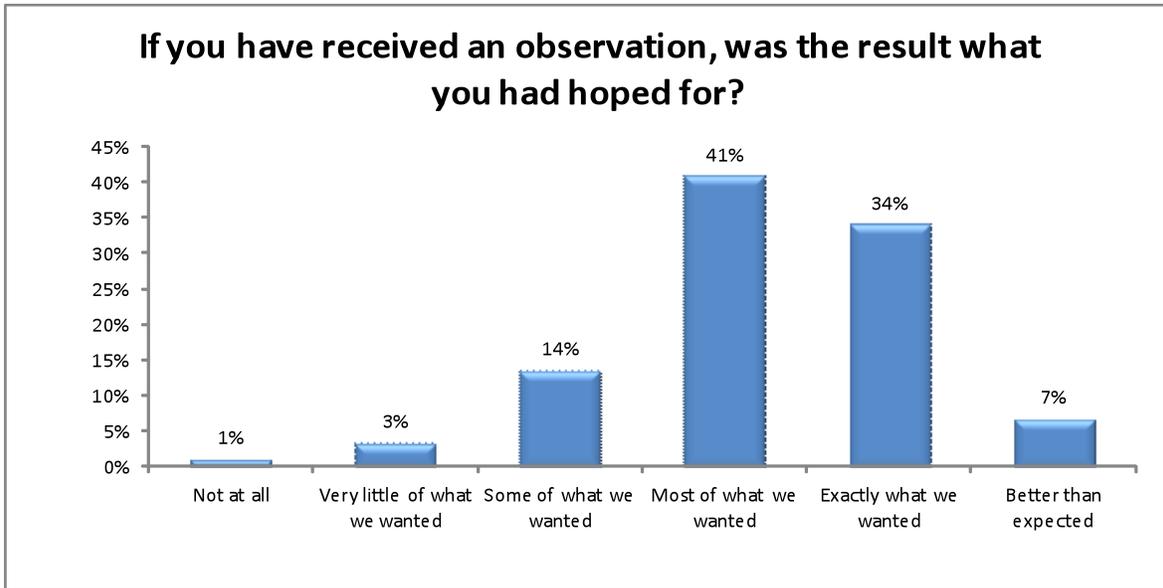
Figure 10



In relation to other issues, over a third used NSO activity to inform lesson planning, to support Astronomy courses or for professional development. About 70% of respondents used NSO in relation to 14-16 year olds, with about 40% using it for post 16 and slightly fewer with 11-14 year olds. 13% used it with primary age pupils, and small numbers noted using it with adults or parents.

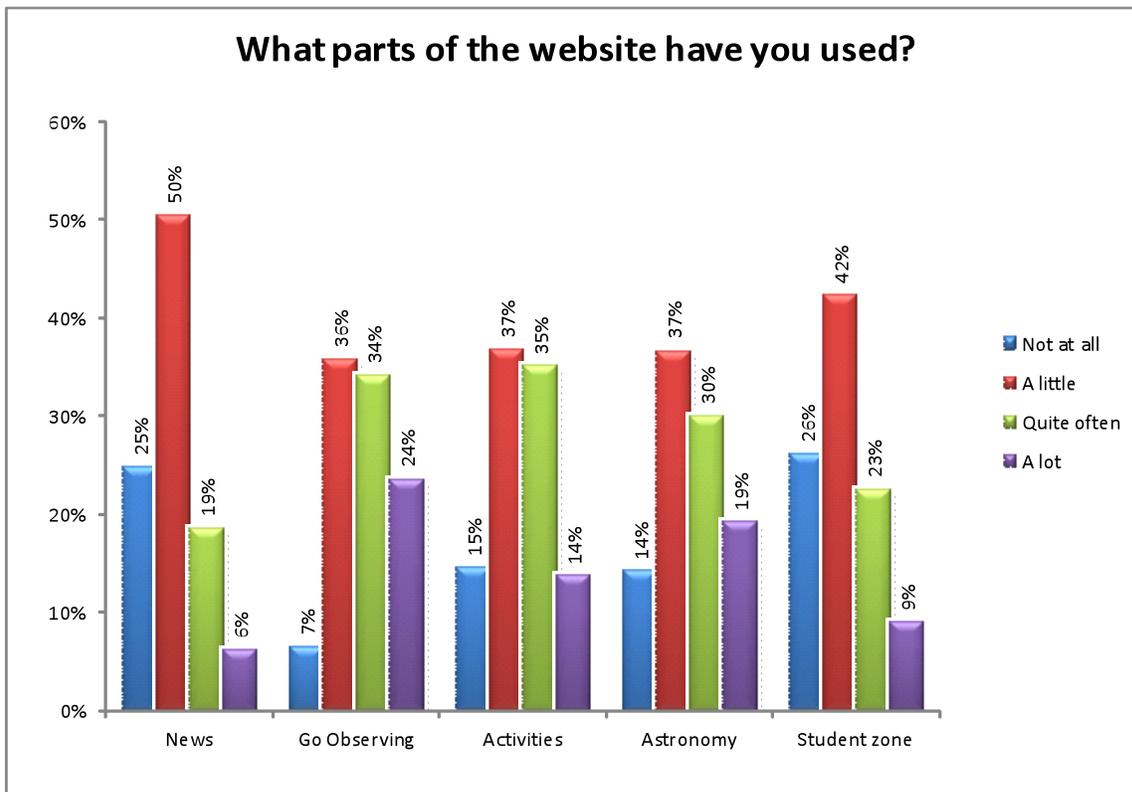
70% had asked for an observation to be done by the NSO telescope. Of the 70% who had an observation done, 71% got exactly what they wanted or a better outcome, an a further 41% got most of what they wanted form it. 14% got some of what they wanted with only 4% getting very little or nothing of what they wanted from it. See Figure 11.

Figure 11



The most well used elements were Go Observing (used a lot by 24%), astronomy (used a lot by 19%) and activities (used a lot by 14%). The least well used were the student zone (used not at all by 26%) and news (used not at all by 25%). See Figure 12.

Figure 12

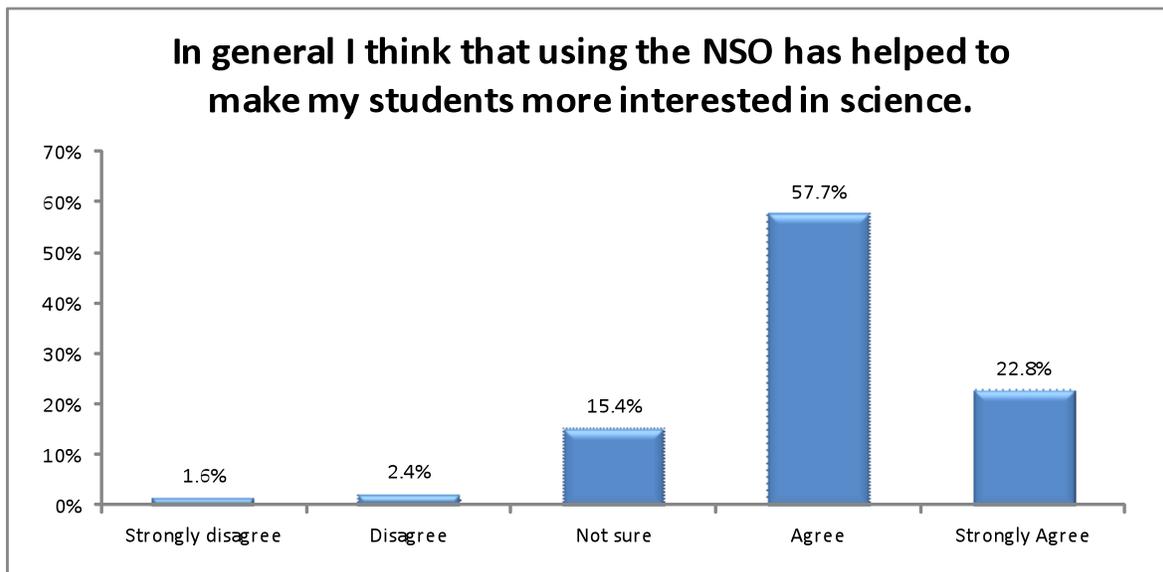


The majority of respondents (60%) had used the NSO in the last 3 months, although 20% had used it more than a year ago. More than half of respondents had used the NSO more than 5 times, with only a small proportion (3%) using it just once.

Impacts of the NSO

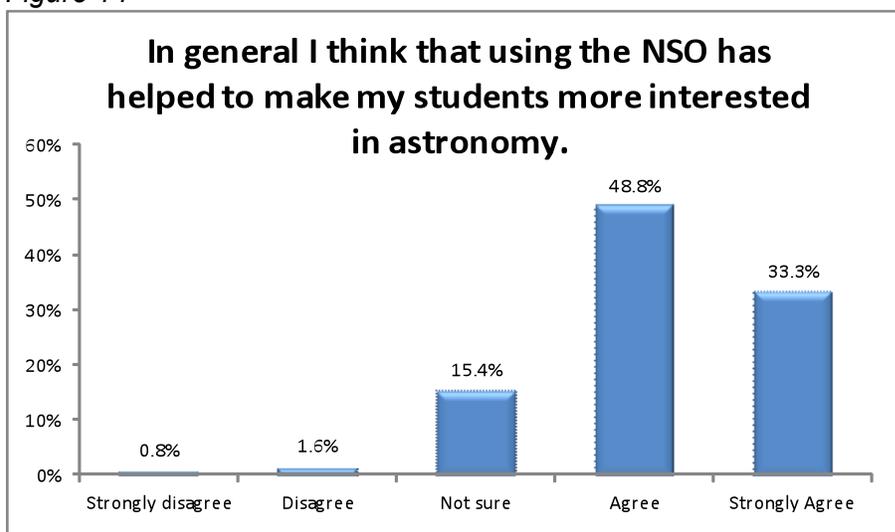
This part of the survey provides evidence that the NSO is having a significant impact on pupils' attitudinal outcomes for science and astronomy. About 80% of respondents agreed or strongly agreed that the NSO had made their students more interested in science with 23% strongly agreeing. Just 4% disagreed or strongly disagreed with this statement. See Figure 13.

Figure 13



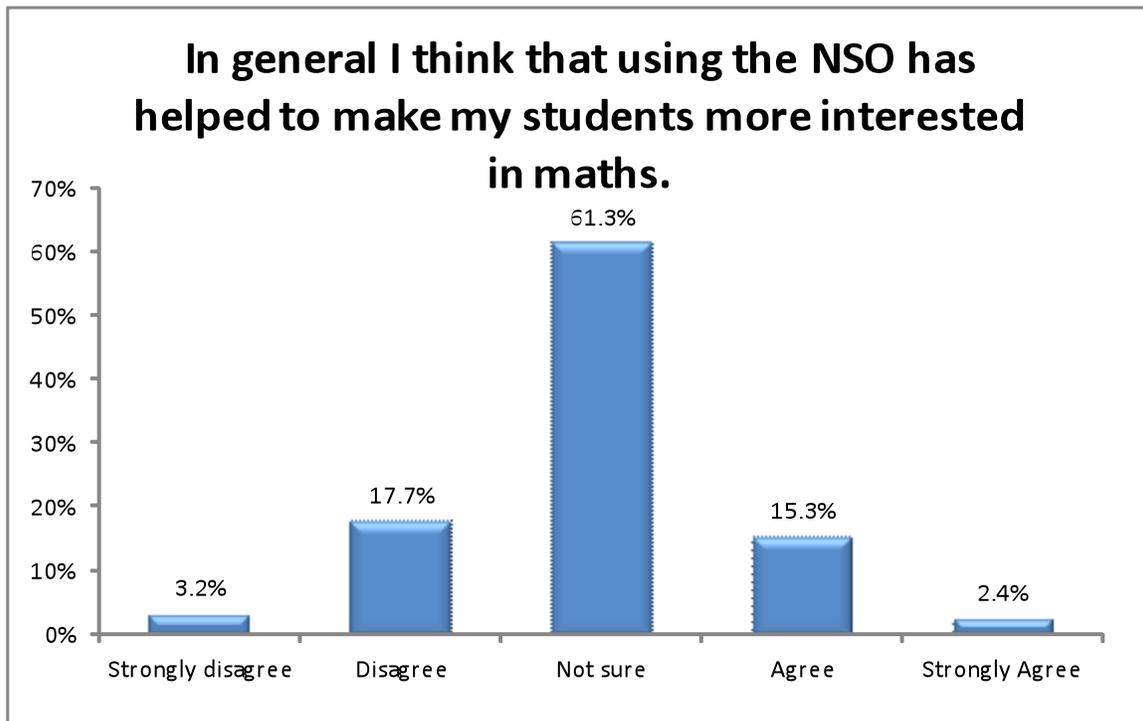
About 82% of respondents agreed or strongly agreed that the NSO had helped make their students more interested in astronomy with 33% strongly agreeing. Just 2% disagreed or strongly disagreed with this statement. See Figure 14.

Figure 14



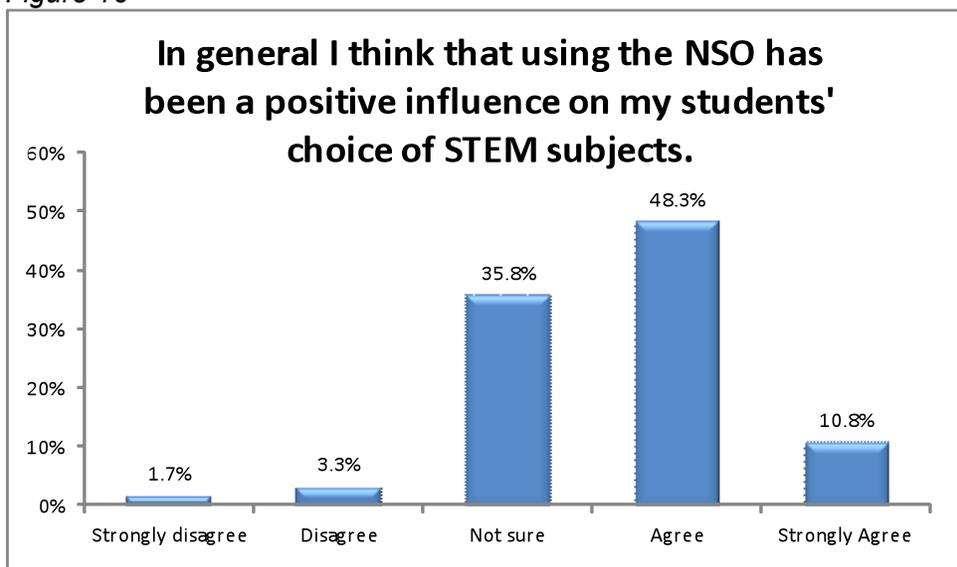
A much smaller proportion - 18% - of respondents agreed or strongly agreed that the NSO had helped make their students more interested in maths, with 21% disagreeing or strongly disagreeing. The majority - 61% - were unsure. See Figure 15. Evidence from the school visits indicates that maths is not prominent in how the NSO is used.

Figure 15



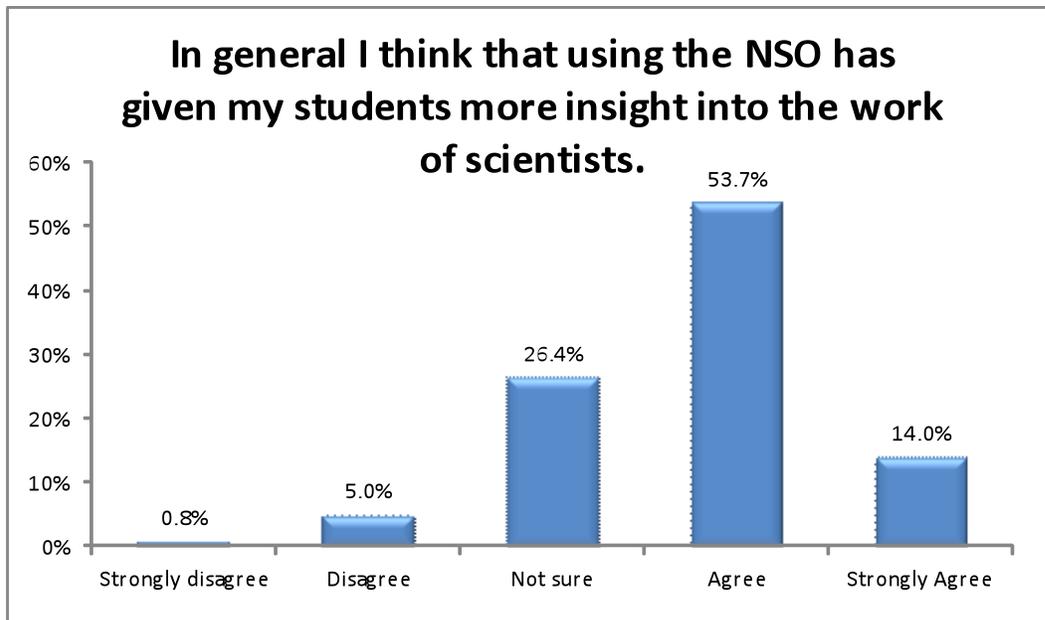
Nearly 60% of respondents agreed or strongly agreed that the NSO had been a positive influence on their students' choice of STEM subjects. Just 5% disagreed or strongly disagreed with this statement. See Figure 16.

Figure 16



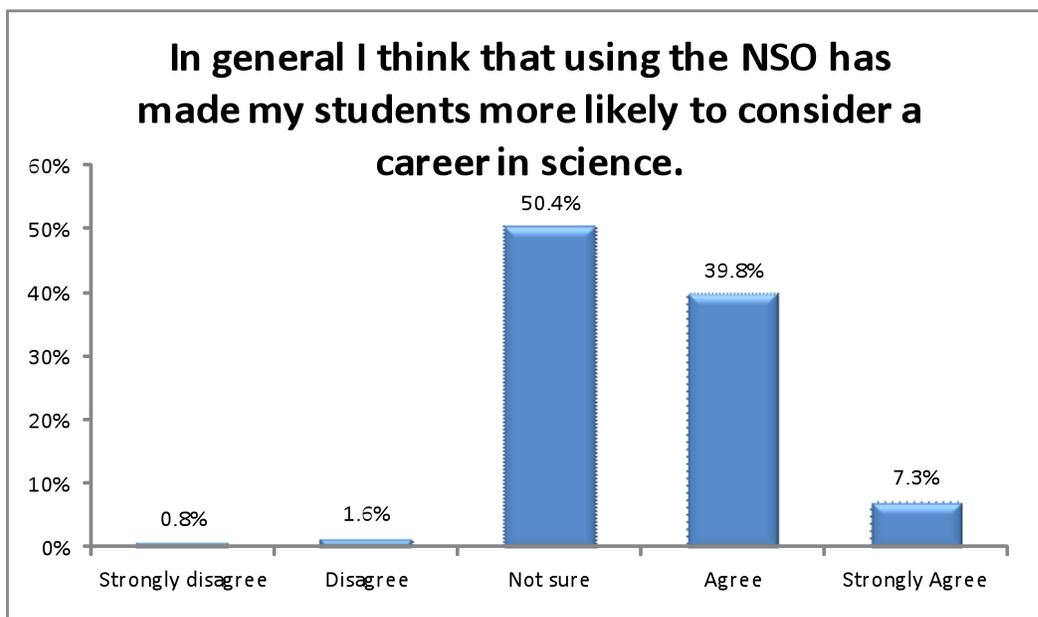
About 68% of respondents agreed or strongly agreed that using the NSO had given their students more insight into the work of scientists, with 14% strongly agreeing. Just fewer than 6% disagreed or strongly disagreed with this statement. See Figure 17.

Figure 17



Furthermore, 47% of respondents agreed or strongly agreed that the using the NSO had made their students more likely to consider a career in science. About half were not sure, and just 2% disagreed or strongly disagreed with this statement. See Figure 18.

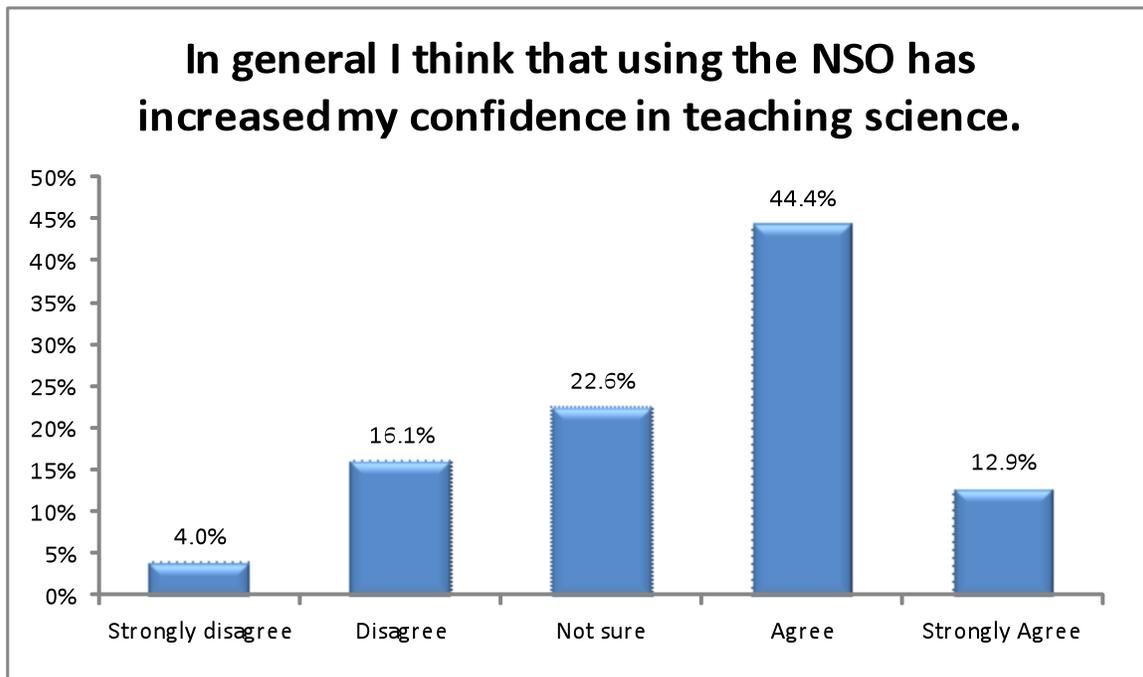
Figure 18



Turning to outcomes for teachers themselves, about 57% of respondents agreed or strongly agreed that using the NSO had increased their confidence in teaching science

with 13% strongly agreeing. 20% disagreed or strongly disagreed with this statement. See Figure 19.

Figure 19



The vast majority of respondents - 84% - felt very confident that they could use the facilities offered by the NSO website and telescope, whilst only 7% disagreed or strongly disagreed with this statement.

80% of respondents agreed or strongly agreed that using the NSO had improved their knowledge of astronomy, with 21% strongly agreeing. 11% disagreed or strongly disagreed with this statement.

This is significant outcome, as teachers' subject knowledge is often not prioritised in school CPD policies.

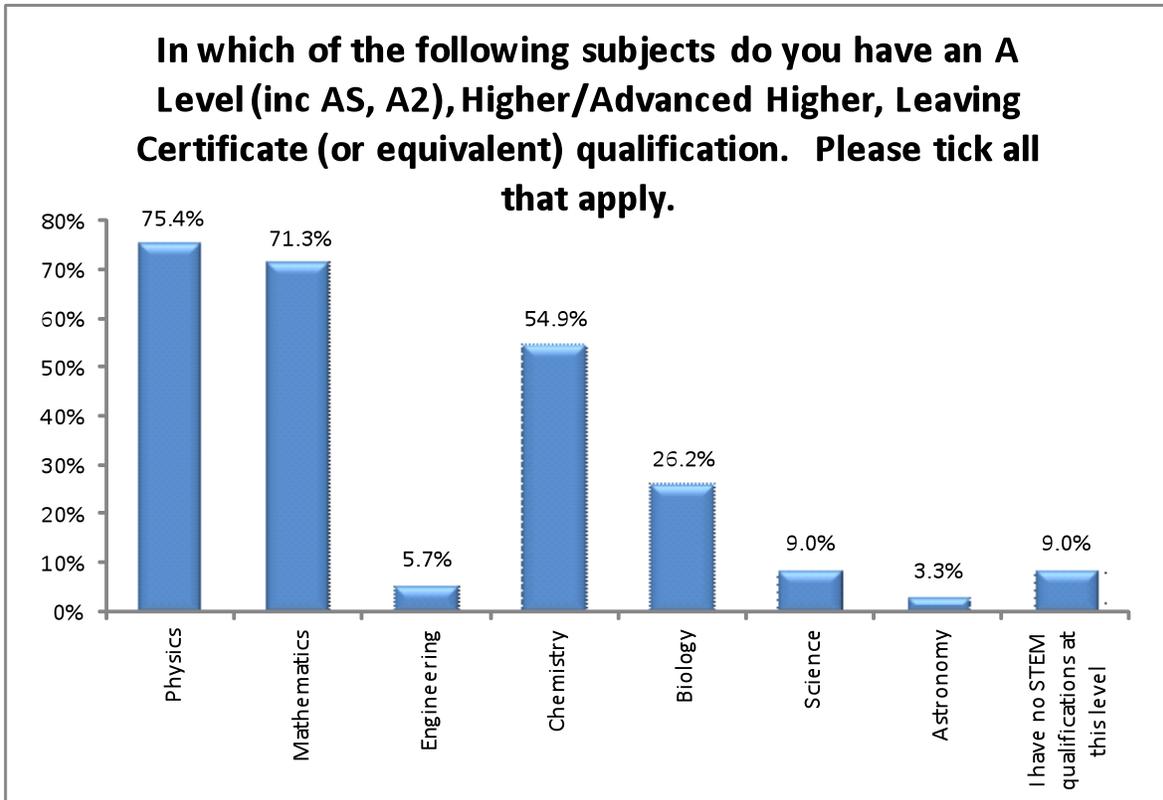
Training and qualifications

Only 6% of respondents didn't require training in the use of the NSO facilities. The most common preferences for such training were online courses (57% of respondents) or one-day courses (53%), followed by online help (40%). There was little appetite for longer courses.

Turning to respondent qualifications, 89% held a GCSE or equivalent in Mathematics, 83% in Physics, 71% in Chemistry and 56% in Biology. Only 12% had an Astronomy GCSE or equivalent, and only 3% held no STEM qualification at this level.

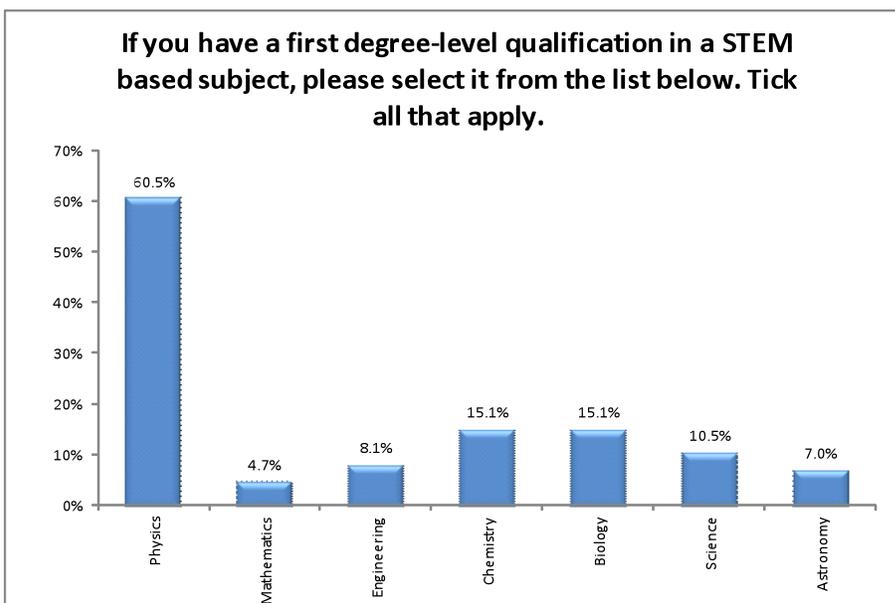
75% held an A level or similar in Physics, 71% in Mathematics, 55% in Chemistry and 27% in Biology. Small numbers held other STEM A level or similar qualifications, with 9% having no STEM qualification at this level. See Figure 20.

Figure 20



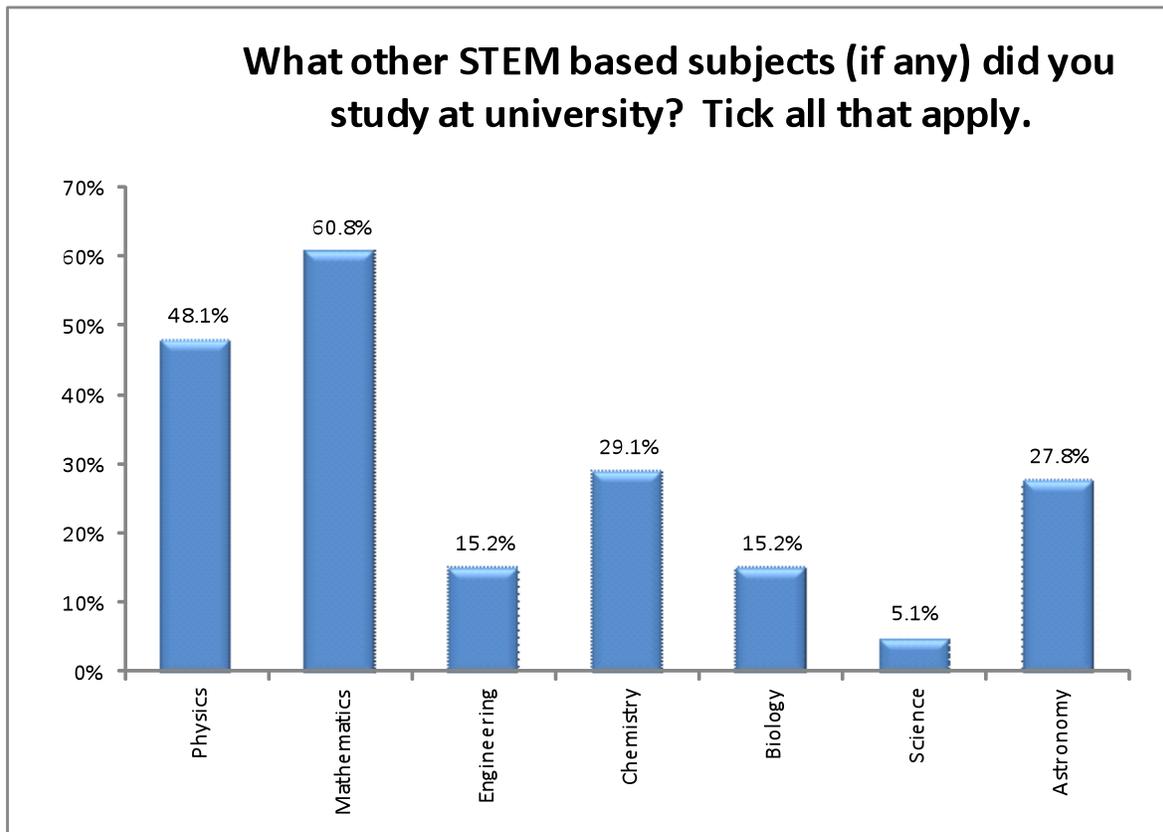
81% of respondents held a Bachelors degree, 27% a Masters and 11% a doctorate. 68% of respondents stated they held a first degree in a STEM-based subject. Of these, 61% held a physics degree, 15% in Chemistry, 15% in Biology, 10% in Science, 8% in Engineering and 7% in Astronomy. Others held degrees in a variety of other STEM subjects. See Figure 21.

Figure 21



When asked about other STEM subjects studied highlight maths, physics and astronomy as the main subsidiaries. The high proportion of Astronomy responses, 27.8%, linked with the 3.3% response for 'main subject studied' shows that around 30% of users have studied astronomy at university. See Figure 22.

Figure 22



Suggestions for improvements

Around half of the respondents responded to the open question 'How could the NSO be improved?'. The responses clustered around three broad areas.

Firstly there was a set of issues around the **observations** mentioned by at least 10 respondents. 7 of these referred to improving the choice of objects, and several asked for responses to be made more quickly. Another 4 requesting that the process of requesting and receiving observations be simplified:

Some of my students used the NSO to make observations for Astronomy GCSE projects but their results were poor. The processing software was found to be difficult to use and not intuitive. They spent a lot of time either waiting or working on material which turned out in the end not worth the wait and would have been better off choosing another title. I am sure it could be better. As Astronomy GCSE is extra curricular a teacher will not have the time to master the process for them and so needs to be pretty straightforward for a 15/16 year old to follow.

This comment links to the second major area: making the website and its content more **pupil friendly**. For some, this related to observation and object choice, others suggested the language and interface could be improved. There were a group of at least 6 comments asking for the content and interface to be developed for younger pupil, especially in Key Stage 2, for example:

Many items are obviously for older pupils, hence many of the questions above do not apply to primary schools. However the pupils do love to see pictures taken of different planets and galaxies and a special section with just photographs for younger pupils to access would be ideal.

Finally, a set of comments relate to more **general improvements to the website**. This included suggestions about developing the gallery of photographs and images; pod casts; the language of the news items; providing email updates; and improving the interface. There were some comments about the software used for images being inaccessible for some, suggestions about ensuring the site was accessible for newer devices such as I Pads, and a set of issues asking for content that linked clearly to the GCSE Astronomy requirements, for example:

Monthly podcasts or videos of the Night Sky report; Videos of Astronomy lectures or other highlights. More activities for the GCSE Astronomy course.

It should be noted that there were also a number of positive comments such as:

The general layout and the variety is excellent :)

The NSO has improved a lot since it first started. any suggestions I have had have been acted on.

very interesting and useful for teachers and students

I think you guys do a great job as it is!

I am very happy with the service provided by the NSO and hope to make more use of it the future.

Keep going! great idea.

I have no further suggestions.

It is a wonderful service that is on offer.

6 School case studies

Six schools were visited, 5 in England and one in Wales. The NSO team had selected a short list of schools, and the final six selected by the SHU team.

The six case studies are presented here, followed by a short cross-case commentary.

6.1 Case studies

Chelmer Valley High School, Essex

Chelmer Valley High School is a non-selective academy with around 1100 pupils aged from 11 to 18. The school has been a specialist engineering school for eight years and has recently been granted a second specialism as a leadership partnership school. In 2007 and again in 2011 the school was judged by Ofsted to be outstanding.

We interviewed the Head of Physics and 2 male & 1 female students. The students had just finished their AS level studies.

Four years ago, the teacher, who has a degree in astrophysics, spent part his teacher training at the school. He was keen to offer astronomy to the students and a year later, when he joined the school as a teacher, he introduced a GCSE course. Initially the course was offered only to the gifted and talented students but it is now open to everyone. It is an extra curricular course but the teacher hopes it will soon become part of the mainstream curriculum. The course usually starts with about 18 pupils; of whom about ten students eventually take the GCSE exam, a few students do not take the exam, they take the course because they are interested in astronomy and a few pupils drop out of the voluntary after-school class.

The teacher originally found the NSO website by Googling for resources; he had not known of it before. Since that time he has become an enthusiast for NSO and has used the site increasingly for both GCSE and A level. He has also used the NSO for G&T science workshops and at the end of Year 12 students about to start A2 physics have used the system to hunt asteroids with the possibility of becoming published scientists. Two of the students interviewed had not used the NSO system previously but said they have enjoyed their recent introduction, which has made them excited about the A2 space module.

The teacher has also attended 2 NSO teacher training courses, one with colleague who is also now teaching astronomy but is a chemistry specialist. He would also like a visit from NSO but said that he had “not been lucky yet”.

When asked how students used the site he said that some had used it for coursework and some of next year’s students were intending to use it for Lunar observations which he said was “a great part of the website”. He also said they had used the site for asteroid hunting and to study images in three colours. Recently the students downloaded three colour images, which they processed; he said that they were emailing him with more and more images. “This is fantastic”, he said, “this is exactly what this website should be about, giving them [pupils] the tools to go away and do it for themselves”.

Students said that they had gained from seeing an application of physics, rather than just theory. They also felt that the image produced was their own observation they said that they felt “like you are doing something in physics instead of experiments where everybody already knows the answer”.

Students are able to apply the scientific procedures they have learned in physics to what they do on-line by understanding the use of appropriate filters and exposure times for example. In future the teacher would also like to use the site to help teach aspects of physics, such as refracting and reflecting telescopes. The teacher also felt that he had benefitted from the NSO training courses and was now using some of what he had learned in his physics lessons.

Asked whether he thought that use of the NSO had affected students' interest in science he said that he thought so. About 80% of students who had taken GCSE astronomy are now taking A level physics, 40% of whom are girls. Some students, especially the girls are now thinking about doing physics at a higher level. The teacher said that he thought that use of the NSO was definitely a contributing factor.

Although he thinks the website is "fantastic", he would like to see a slightly better indexing system in order to see more easily what is available on the site; he said he often tends to find things by accident. He also said that if possible he would like to see tighter links to the astronomy and physics curricula specifications.

Tapton School, Sheffield.

Tapton School is an 11-18 comprehensive school in a suburb of Sheffield, recently classed as 'Outstanding' in a recent (December 2012) OFSTED report. It is a Science and Arts College, and has Academy status, being part of an Academy Trust, with Chaucer School, a north Sheffield comprehensive. There are 1657 on the school roll, of which 479 are in the sixth form. Attainment is above national averages.

We interviewed a science teacher and three Y9 pupils who had made use of the NSO. The context of NSO use was an all ability astronomy club the teacher had set up – he is an amateur astronomer, and had also carried out several science-related jobs prior to becoming a teacher. He had been using the NSO since around 2009, and had also, in the past, used the Bradford Robotic Telescope. NSO activities were used as extension activities, rather than being embedded in the curriculum. The NSO created a sense of excitement in the pupils, and use of mini-competitions ('the best pictures will go on the school website') increased pupil motivation. Pupils stated that among all the activities they did in school, working with the NSO was the most exciting. They particularly appreciated the fact that they were using a real, professional telescope, and that they were able to plan their use of the NSO around other activities, as there were no set time-slots for requesting images.

Using the NSO had increased pupil skills and confidence, which carried over into science lessons. All three pupils were intending to study Triple Science next year, although none suggested that using the NSO had helped with their mathematics studies. Using the NSO had increased their awareness about the breadth of science careers; one said, "I used to think there were just astronomers and astronauts", but then went on to list a series of jobs that they knew about related to astronomy and space science, including the engineers who build equipment and instruments.

The teacher agreed that using the NSO had enhanced pupil motivation and enthusiasm in science, and that it had impacted on pupil knowledge and understanding, skills and confidence in science. With a wide range of experience of other STEM initiatives, he suggested that the on-going nature of the NSO (i.e. it was not a one-off event) was part of the reason why it was having such a positive impact on pupil attitudes. Pupils of all abilities

were involved, with differentiation by task enabling the teacher to deal with a wide range of ability.

When asked about how the NSO could be improved, it was acknowledged that it was a superlative resource. Suggestions for improvement included:

- Addressing an issue in the web browser Internet Explorer which meant that when the Save button was pressed, the image is opened up as raw digital data
- Making 'where are we with our requests' available for users to keep track of what they had requested, perhaps as a feature users see when they log in
- Making the images available in a wider variety of formats, not just being able to export as a JPG file. Inclusion of more sophisticated image manipulation software.

The teacher and pupils were extremely positive about the impact of the NSO, and were keen to see it continue long into the future.

Castell Alun High School, Flintshire

Castell Alun High School is a co-educational 11-18 comprehensive school in Flintshire, northeast Wales. It has 1330 students, and is an English-medium school. As a Welsh school, it does not feature in the DfE Schools database for comparison purposes, however it's success in GCSE examinations (75% achieving 5 or more passes at grades A*-C) is well above the English national average.

We interviewed an experienced physics and science teacher, and a group of 3 sixth formers, all of whom were current users of the NSO. The teacher had originally become aware of robotic telescopes via the Faulkes telescope, and had found the NSO when carrying out web searches for astronomy resources to use in a new GCSE Astronomy course in 2009. This led to the teacher meeting the NSO team, and several examples of school-NSO interactions have taken place since (including collaborating on an bid to the STFC, and involvement in student workshops). The teacher had a passion for Astronomy since childhood, and went on to study Natural Sciences at the University of Durham. Engagement with the NSO had 'refire' her when, shed had begun to 'flag'. It had given her a 'new lease of life'.

The NSO is used in GCSE Astronomy (taught after-hours), and is being introduced into GCSE Physics in 2013-14. Pupils also use the NSO at lunchtimes, and after school. It helps with the mathematics content of the GCSE Astronomy course (eg measuring the size of a galaxy, or measuring velocities), but is not used in mathematics lessons. The teacher finds the quality of NSO resources to be excellent - "it all works, it is stress-free". The students, who had done the GCSE Astronomy course, found the NSO easy to access and use, particularly for course work. They considered it invaluable for the course. They also found that it had helped with the GCSE physics, although this was with a different teacher. They had used the imaging service, but had used other parts of the NSO website, and had even compared the NSO with data obtainable from other robotic telescopes, but found the NSO to be best.

Both the students and the teacher agreed that using the NSO had increased student interest in Astronomy and science. Indeed, the teacher gave an emphatic 'yes' to this question. The students stated that it had also increased their skills and confidence in science. They particularly liked using 'real terms' that can then be used elsewhere in their science studies. Again, both students and teacher agreed about the positive impact on awareness of careers in STEM subjects - one had obtained a work placement at LJMU as

a result of the teacher's involvement with the NSO. It also raised awareness of the breadth of careers related to astronomy and the use of telescopes. The teacher suggested that learning Astronomy, and using the NSO, had provided added confidence to the students in science, as they were learning something outside, or above the content of the other courses.

Suggestions for improvements included increasing NSO publicity, as (in their view) 'not enough people know about it'. If the focus of the NSO shifts more to post-16, then the KS3 offer must be maintained or enhanced, as this was a key 'decision time' for pupils considering GCSE choices.

Aquinas College, Stockport

Aquinas College is a popular Catholic Sixth Form College in Stockport. Stockport is one of the most diverse boroughs in England, overall it is a relatively prosperous area with low unemployment but there are local pockets of high deprivation. The college has for many years been oversubscribed having around 2000 students aged 16 to 18; the majority are full-time students studying advanced level AS and A2 courses. The college also offers vocational courses in business, sport and performing arts at levels 2 and 3, a re-sit GCSE programme and a 'Skills for life' course for a small number of students with moderate learning difficulties. In November 2008 Ofsted inspectors called Aquinas an outstanding college.

We spoke to a male science and maths teacher and 2 female AS students.

The teacher has had an interest in astronomy since taking an undergraduate degree in physics but knew about the NSO because he had been part of the NSO marketing team for a number of years. Since leaving the NSO he has been teaching full time at Aquinas College and two years ago took the opportunity to set up a GCSE astronomy course. This is an enrichment course for the A level students aimed mainly at physics students to prepare and interest them in the astronomy, cosmology and space elements of the physics course. 16 students took the course last year and 13 are enrolled this year. Not all astronomy students are studying physics, last year a non-physicist took the course for interest and a non-examined course was run for interested adults.

A raft of different resources is used for the courses, for the GCSE course the NSO site is used primarily because students have to do aided and un-aided course work. Students are introduced to the course, shown the 'Liverpool' telescope and how they can take 'wonderful' images and do analysis for themselves. They are then given instruction in the use of the system and left to decide which images they should take. Because the course is only one hour a week and they are studying at A level, students do have to do a lot of independent learning.

The NSO site was used in the recent adult course, participants were registered and encouraged to request their own images. The NSO site is also used as part of the AS and A2 courses where elements of the physics specification such as detectors can be demonstrated and students can see the effect of looking at the same NSO image using different wavelengths infra red, ultra violet, x rays and visible spectrum. The teacher thought that access to the system had raised interest in science amongst his students he said it was an inspiring way to teach science. He also teaches maths and tries to overlap physics and maths where possible; a particular example was using the NSO site to talk about calibration and resolution.

The impact of the astronomy course was confirmed by the two students both of whom said they were considering a degree involving astrophysics and that the astronomy course and opportunity to use the Liverpool telescope had been a factor in that decision. One of the girls has arranged her next work experience at Jodrell Bank.

While he is an undoubted enthusiast for the system when asked how the NSO could be improved the teacher had a number of suggestions.

He thinks that it would be useful to have a local hub with a set of satellite schools set up by the NSO where schools can share expertise and enthusiasm.

He felt that the site could be developed for primary pupils; having shown the site to a primary teacher she said it's wonderful but there's not much for my pupils.

He thinks that projects and lessons need to be re-vamped, with big input from practicing teachers. Ofsted expects outstanding lessons where students are inspired through the opportunity for hands-on involvement, discussion and the chance to develop their own learning. He would like NSO projects to have a short snappy introduction and then get the students engaged in doing something themselves. Lessons need to be Good or Outstanding and more tightly linked to the curriculum. At the moment he feels there are too many Power point slides, it takes too long to explain things and goes into too much depth. Projects need to fit into lessons of 50 minutes with a plenary at the end and then maybe leave them with more things to do as a follow up or for their own interest.

Overall a more general interest approach for KS2 & 3, tightening up to a more curriculum based approach for KS4 and Post 16.

Horbury School, Wakefield

Horbury School is a medium-sized 11-16 comprehensive school in the large village of Horbury within the city of Wakefield, with just over 1000 students on roll. It is a specialist language college and has Full International School Status. The school was classed as 'Good' following an Ofsted inspection in November 2010.

We interviewed a science teacher and three Year 9 students, a girl and two boys; these students were just starting their astronomy course.

The teacher, who described himself as an ardent amateur astronomer, had suggested to the head teacher, two years ago, that the school should start a GCSE astronomy course. This was to be part of the main curriculum but initially was offered only to students studying triple science. The course has been very successful and this year has been opened to all GCSE students; there are now sixty students studying astronomy. To support the course they use two main websites, Star Learner and NSO. The teacher said that he stumbled on the NSO through Twitter, but he thought that the school might have been registered previously. He was very enthusiastic about the NSO site and the support they offer; Chris Leigh who has been to the school a couple of times and has done one of the lessons on galaxies.

He also said that he has found the LT image program 'incredibly useful'. He said it was 'immensely useful' for doing controlled assessments in astronomy. The group has also used the program with images from the Faulks telescope. He said that students love using the program, they have spent hours using it to try to bring out more detail from the images.

As far as the effect of using the website on students' interest in science, it is hard to say at this stage because students were all taking triple science already. In future it will be easier to make that assessment because the current cohort has students with predicted grades from A* to F. The teacher intends to tailor the NSO resources to fit that range of abilities and hopes that the work done by the higher ability students will help others see the bigger picture and will put their work in that context.

The teacher felt that students' skills had definitely improved over the course, they were able to use the more detailed knowledge gained in the astronomy course in triple science physics. He felt that astronomy brings different subjects together brilliantly, not only physics and maths but the possibility of extra terrestrial life. This element of putting things in context was echoed by the students. The astronomy course has already had a big influence and he believes that NSO will have a long-term impact because it enables students to find high quality information easily. He believes that the website will help to maintain their interest.

When asked why they had opted to take astronomy the female student said that she had previously been interested in astronomy but what interested her most was the possibility of life on other planets and the type of planets that might give rise to life. One of the boys said that he wanted the GCSE astronomy qualification because he would like to become a commercial pilot; the second boy said that he wants as many science qualifications as possible in order to go to a good university

The teacher and students liked the layout of the website saying that it was straightforward, intuitive and easy for students to use. The teacher said he thought the site was a brilliant help and the students said that it was really useful.

Penwortham Priory academy, Preston

Penwortham Priory academy is a High Performing Specialist School for Sports and Technology situated in the Penwortham district of Preston. The school caters for students from 11 to 16 and is smaller than average with just over 700 students on roll. It also has a higher than average proportion of boys compared to girls. The school was classed as 'Good' overall when inspected by Ofsted in May 2010.

We interviewed two female teachers and two male KS3 students. The teachers, both physicists, were the current and previous Heads of Science.

The school originally learned about the NSO from an email sent about 5 years ago from John Moores University to the previous Head of Science. She felt it would be an opportunity to expand the Physics curriculum and possibly make links with further and higher education. She expressed an interest in her students visiting John Moores University to give them an HE experience other than UCLAN (University of Central Lancashire in Preston). Although the school registered with the NSO 5 years ago, little more was done after a change of science leadership to a non-physicist. In the last 12 months, following another change of departmental leadership, the current Head of Science arranged to receive an Astro Tour from Andy Newsam.

Only students who were members of the STEM club were involved in the programme but the teachers wanted to use the visit to launch astronomy and the NSO within the school. Next year astronomy will be introduced as a four week topic in Year 7 and a GCSE in Astronomy will be offered as an extra curricular activity at Year 9. They expect to use the NSO site for both information and interest.

Because of the limited use of the NSO website so far, it was difficult to say how it had affected students' attitudes; members of the STEM club are already interested in science, but one or two members of the club have become particularly interested in astronomy. This corresponded with the students' opinions; both boys said that following their experience with the NSO site they will opt to study the GCSE in astronomy next year and one of the students has requested more pictures for his own interest.

One of the students said that after the visit by Andy Newsam and seeing what other people did on the website it has made him think; 'Maybe I could do that'.

Both staff and students were very positive about the website and said they found it easy to navigate, although the students had mainly used it to order pictures. Both staff and students wanted a more iPad friendly site, all students in Years 7, 8 and 9 and next year 10 have iPads and as desktops fail they are not being replaced. Some of the NSO website is Flash based and it was suggested that if the website was more 'iPad friendly' it would be used more by students and would be easier for teachers to integrate. They also said they would like student friendly emails and a Twitter feed aimed at younger (KS3) students.

One of the teachers said that she believes that opportunities like this are very much down to the drive of particular teachers; however leadership teams are looking for more academic subjects and interests for students. A Year 9 GCSE in astronomy for the most able students could also engage students in the maths and science involved in astronomy and she would like to see more physics and particularly maths in context on the NSO site.

6.2 Cross-case commentary

Three 11-18 schools, two 11-16 schools and one post-16 college were visited. Involvement with the NSO was due to one (2 in one school) teacher with a passion for astronomy, rather than because of school STEM policies or programmes. Although the explicit impact of school management on involvement was not evident from the interviews, 5 of the schools were offering GCSE Astronomy, which had to have management sanction. It is perhaps the case that the teachers engaging with the NSO would do so in whatever management environment they found themselves in, as enthusiasts, passing on their enthusiasm to their pupils and students. This is unlike some other STEM interventions we have studied (eg the Big Bang Fair; Afterschool STEM Clubs) where the impact of the intervention is to some degree mediated through the level of support provided by school management.

Teachers came across the NSO through a variety of ways, including web searches and Twitter, with only one school citing a 5-years ago email from the NSO to the then head of science. One of our recommendations relates to the need for effective marketing, although the evaluation team's experience of running STEM interventions requiring teachers to 'sign up' is similar. It seems that no end of marketing campaigns is needed to gain a foothold in teachers' repertoire of teaching and learning activities.

For all but one school, the main focus of use of the NSO was through GCSE Astronomy. Some made use of the NSO to support A level courses in physics (one quoted the A2 Space module in physics). These GCSE courses were run out-of-hours, indicating a high degree of commitment to the subject.

In general, use was made outside science or physics lessons, eg at lunchtime or in after hours clubs and courses. This is understandable given the link with GCSE Astronomy. Using the NSO provides an authentic context and experience of science, as the Chelmer

Valley case study highlights: 'like you are doing something in physics instead of experiments where everybody already knows the answer'.

In all schools, the impact on pupil and student enthusiasm and interest in science was significant. Given the self-selecting nature of most groups involved with the NSO, a high interest and enthusiasm for science would be expected. However, the NSO has further increased these pupils and students positive attitudes, and focussed many towards future subject and career choices in Astronomy and Space Science. Their confidence in astronomy and science has increased, in particular through the autonomy that the NSO activities require, and the engagement with real, authentic science. It provides them with a taster of what astronomy, space science, and indeed, science, is like in the professional world. This is careers education in its purest form – no need for the hard-sell careers approach. The students learn about careers by doing scientific activity, engaging with a 'real world' facility, and become aware, along the way, of the types of job that people in the astronomy and space science do – 'they learn that it's not just astronomers and astronauts', as one teacher said.

In most schools, the selecting group were ones who were likely to attain sufficiently highly to progress onto A level courses in Physics. Some schools used the NSO with Gifted and Talented pupils, but at least one school involved pupils from a wide range of ability.

7 Achieving the intended outcomes; hypothesis conformation; reach and significance

Here we take the intended outcomes and determine if there is sufficient evidence from the evaluation to suggest that the outcomes are being achieved.

7.1 Shorter-term outcomes

Increased interest in science (STEM)

Whilst the level of interest in science amongst the pupils completing the questionnaire is significantly higher than the levels identified in a more random sample of pupils, respondents report emphatically that their interest has been increased through engagement with the NSO. Figure 7 shows that 48% the pupils, who were already interested in science, were reporting that the NSO had made them more interested.

Over 80% of the teachers agreed (or strongly agreed) that the NSO had helped to make their pupils more interested in science. Slightly more thought it had made their pupils more interested in astronomy.

Some STEM interventions (such as STEM Ambassadors) are targeted at all pupils, and part of the purpose of such schemes is to switch pupils on to STEM subjects. The NSO fulfills another vital need (in our view) – that of keeping and building on the interest of those who are already positive about science.

There is evidence that this outcome is being achieved.

Increased awareness of the applications of science

We have broadened this to include the idea of ‘authentic science’ – that is, scientific activity in school that makes use of or (to a greater or lesser extent) mirrors scientific activity in the professional world. The NSO provides pupils and teachers with an example of real science in action. Appreciation of this came through strongly in the interviews in school. Pupils felt that this was something special, something that transcended the ‘we know the answer already’ type of science practical work all too common in our schools. Over 60% of the pupil respondents indicated that using the NSO had helped them to understand what sort of work scientists do. Almost 70% of teachers think that the NSO has given their pupils more insight into the work of scientists.

There is evidence that this outcome is being achieved.

Increased awareness of STEM careers

Effective STEM Careers education (not often an explicit aim of STEM interventions) includes bringing young people into contact with scientists, and the outcomes of their work. The NSO does this, providing young people with an increased level of awareness of what scientists do, as highlighted in the previous paragraph. In the view of 46% of teachers, the NSO has also made their pupils more likely to consider a career in science. Evidence from

the school visits also provides evidence in support of this outcome (see cross-case commentary, above).

There is evidence that this outcome is being achieved.

More informed and enthused Astronomy students

Evidence from a range of questions (about awareness of scientific careers, future subject choices, interest in astronomy) all point to the achievement of this outcome. 68% of pupils agreed or strongly agreed that using the NSO had made them more interested in astronomy, and over 80% of teachers agree. In effect, this gets to the heart of what the NSO is for – increasing engagement with astronomy.

There is evidence that this outcome is being achieved.

More engaged teachers

A number of the teachers interviewed on the school visits indicated they had been searching for resources online when they came across the NSO. What then resulted was their recruitment to the user-base of the project. Responses to questions about increased confidence as a result of using the NSO show over 50% of teachers agreeing or strongly agreeing with the idea that this had resulted in increased confidence in teaching science (also providing evidence of the outcome below). Over 90% of the teachers also suggested they would be interested in some form of training (split between face-to-face and on-line courses). The face-to-face interviews with teachers provides anecdotal evidence of increased engagement, with one teacher saying with great feeling that the NSO had re-invigorated her teaching. The above examples provide evidence of a range of different types of engagement – from getting involved in the first place, willingness to undertake training, and the impact on the teacher's enthusiasm for the job.

There is evidence that this outcome is being achieved.

Increased teacher knowledge and confidence

This links with the outcome above to some extent, and our assessment of the achievement of this outcome is based on the same evidence base.

There is evidence that this outcome is being achieved.

7.2 Longer-term outcomes

This evaluation was not based on a quasi-experimental model involving pre- and post-intervention data collection and the use of a comparator group. It was more of a snapshot of teacher and pupil self-reported views, as the timing was such that all respondents had been engaged already with the NSO, ruling out a pre-intervention phase for the evaluation. It is also a one-off evaluation (although the NSO team might repeat it in future), with no follow-up phase planned to investigate subject choice and career destinations for participating pupils or to monitor long term changes in teacher behaviour, reflecting increased skill, knowledge and confidence. As such it is difficult to make definitive statements about evidence for the achievement of the longer-term outcomes. The longer-term outcomes are:

- Increased positive attitudes to STEM subjects and careers

- Greater attainment in STEM subjects, and uptake and attainment in GCSE Astronomy
- Higher level of teacher skill in dealing with Astronomy

As for positive attitudes to STEM being maintained on the longer term, our evidence from other research (Engineering Science, Big Bang Fair) is that multi-nodal interventions have a greater chance of achieving sustained increases in positive attitudes. We have characterised the NSO as a multi-node intervention (ie there are a series of interventions over a period of time, rather than a one-off involvement). As such, it is more likely than not that if we returned to question the same pupils in a year's time that their levels of interest would have been maintained.

Increased attainment in STEM subjects can be directly measured by analysing exam results, although care would need to be taken in identifying a suitable comparator group, and a reliable measure for the value-added component of attainment that relates to NSO use. Uptake in GCSE Astronomy would be simpler to measure, and to some extent there is evidence in this evaluation that an increase has occurred, although before-and-after statistics are not available, for the difference over time to be more precisely measured.

Similar problems also occur in terms of identifying sustained increases in teacher skill and confidence. The multi-nodal nature of the NSO leads us to believe that this longer-term outcome will also be achieved, although objective measures of teacher skill and confidence might be problematic, and there would be a need to rely on self-reporting, or with sufficient resources, observations of teachers in the classroom.

Having said all this, it is our professional judgement that the longer-term outcomes are highly likely to be achieved.

7.3 Programme hypotheses

To some extent, this section of the report is for the evaluation team, and to assist the STEM community to gain greater insight into what makes an effective intervention.

For the NSO, we put forward the following hypotheses:

- In and out-of-school engagement with the NSO helps to maintain students' interest in science/STEM subjects as they get older
- Student skills/confidence will develop through taking part in NSO activities
- Student attitudes to science will become more positive as a result of engaging with NSO activities
- Students' broad awareness of STEM careers will increase through direct contact with STEM professionals
- Multi-node interventions have more sustained impact than single node ones
- Teacher knowledge and confidence increases through working in a purposeful way with NSO activities

These hypotheses were post-hoc constructs created by the evaluation team. They are insights into the underpinning logic of the intervention, and whilst they would have been useful starting points for the design of the NSO offer, in our experience of evaluating STEM projects, programme hypotheses are not generally used for intervention design.

One way of looking at evaluation is to identify the difference between the project planners 'doing the right things', that is, is the design of the intervention likely to achieve its stated

aims, and whether they are 'doing things right', that is, is the design being effectively implemented. The hypotheses relate to the 'doing the right thing' dimension. If they are used to design the intervention, then they could assist the development of the programme. For instance, bearing in mind the hypothesis that multi-nodal interventions have more impact than one-off activities, the design could encourage multi-stage engagement. The way the NSO is used is exactly that – users come to the web site on a number of occasions (whether part of the explicit project design or not – remember, these are post-hoc constructs). However, we are not able to measure the longer-term stability of the changes in pupil attitudes. The best we can do is suggest that, as the theory of multimode interventions seems to hold with other STEM projects, if the project is well designed, to achieve multimode-style involvement, then we can infer that long term attitudinal change should result.

The rest of the hypotheses link quite closely with the project outcomes. The project is designed to achieve these outcomes and there is evidence that the outcomes are being achieved. So, as well as 'doing the right thing', it can also be stated that the NSO team is also 'doing things right'.

7.4 Reach and significance

The NSO is available to schools across the whole of the UK and the Republic of Ireland, and includes primary and secondary schools as well as post-16 colleges. There are around 1000 active users, representing perhaps a slightly lower number of schools (if some schools have more than one registered teacher). Whilst some STEM projects and programmes run by national organisations (such as STEMNET or the National STEM Centre) might be engaged with more schools, in our experience (20 years running and evaluating STEM initiatives at regional, national and international levels) few projects coming from a small regionally-based team have ever reached so many users. Indeed, this author's experience as a member of the EPSRC Partnerships for Public Engagement peer review college since its inception, no university research department's grant-funded outreach or public engagement project has reached even 20% of the number of schools that the NSO, in the Astrophysics Research Institute at LJMU, has reached. Even from the perspective of an independent evaluation, this can be seen as an immense achievement, and reflects the quality of the NSO offer.

Increasing the supply of young people opting to study STEM subjects and take up careers in STEM has been a government priority for many years. The Roberts Review (*SET for Success*, 2002) laid out the parameters for the current priority for increasing the supply of STEM skills, and this and the previous government have invested significantly in a national STEM programme in England, and there have been similar programmes in the devolved nations and the Republic of Ireland. Over the past 10 years, there have been many hundreds of initiatives aimed at schools and colleges to encourage students to make positive STEM subject and career choices. With the exception of national schemes such as STEM Ambassadors, STEM Clubs, and the Science Learning Centres, most initiatives have suffered from short-term funding. Once a scheme is up and running its project cycle will come to an end within a year. It is significant that the NSO has secured funding for the coming 3 years, and this will give it time to build on the team's experience thus far.

The design of the project, as a multimodal experience for teachers and young people, will allow it to make a long term impact on attitudes to science and astronomy, and STEM subjects more generally. Evaluation findings show that it is already having an impact on the uptake of GCSE Astronomy in the UK.

In our view this initiative has an unprecedented reach, and is one of the most significant educational initiatives in the STEM field that is linked to an HEI.

8 Recommendations and criteria for development

With the teachers and pupils who responded to the questionnaires and school visits the NSO is a major success. Just reading through the analyses of the teacher and pupil questionnaires and the case studies shows that on all levels the NSO has impacted in a significant and positive way on young people's attitudes to science, and for many the NSO has opened up what might otherwise been an unthinkable career pathway (unthinkable in that they might just not have thought about it) in astronomy and/or space science. That the majority of participants were positively disposed to science from the start should not detract from this impact. It would be wasteful to put all our energy and resources into switching more young people to science if, once 'recruited' there was nothing there to maintain, expand and deepen their interests. In our view, the NSO's main role is as a 'retention and embedding' initiative, in terms of its role in the national push for more young people to follow STEM subject and career pathways. That is not to say that it cannot be used in the recruitment role as well – it is just that this evaluation found more evidence for the embedding function. We make a recommendation about this, below.

8.1 Recommendations

In summary, our recommendations are:

The NSO resource should continue to be funded at least at the current level, and if possible with additional resource, some of which could be focussed on marketing and communicating the offer to schools.

The NSO team should establish a lead-user group, of between 5 and 10 regular users, but also include some willing non-users. This should be used to test out new ideas, to provide insights from use (as experienced users and novices), to give advice on curriculum resources and to develop a set of quality criteria (which are always best developed by linking project developers to project users) that will guide future developments. They could also review the functionality of the web site, and the use of software, types of images etc (these were subject to some comments by teachers and pupils). Although we provide some criteria, below, our experience is that these are best created by project teams working with teachers or other users. This could be face-to-face (eg with two meetings per year, with teachers' costs covered), virtual, or a mix of the two.

There should be a new marketing and communications plan. Teachers citing Google and Twitter, or 5-year old emails, suggest that 'out there' whatever efforts are being put into recruitment are succeeding only in part, and that there could be a greater pool of potential users – ones who might not spend hours trawling for resources on the web. Reaching them is the challenge, as is reaching out to the teachers for whom astronomy is not a special passion.

The NSO team should carry out (or commission) a review of all curriculum support materials to ensure fit with the curriculum. This is complex, and indeed many teachers

expressed satisfaction with what was on offer. Others, however, suggested a better 'fit' would be an improvement. This could be one of the jobs for the Lead user group.

The NSO team should develop a set of resources and activities that are designed for use by teachers with much less physics and astronomy expertise than seems the norm amongst the responding teachers. For instance, they could be marketed to primary teachers as a way to enhance and enrich their science lessons, but which require little or no astronomical knowledge. These, or similar resources, could also be marketed at teachers of pupils aged 11-14, as a support for science that does not require a 'passion for astronomy'. Both these recommendations would create the potential to expand the user base beyond the current pool of physics and astronomy graduates.

The NSO team should develop a CPD programme that is differentiated, into novice, frequent users, expert users. Novice users could be offered a programme that focuses more on how the NSO could support science teaching and learning, particularly at KS2 or 3 (or other national equivalents).

8.2 Criteria for future developments

These connect with the recommendations, above. They are also presented with an expectation that they are seen as exemplars, rather than definitive criteria, as we suggest that the most effective way to develop such criteria is to involve users (see our Lead-user recommendation).

We have divided these into the following categories

- User engagement
- Curriculum coverage
- Curriculum resources and activities
- Marketing and communications
- Training
- Web site functionality

Issue	Expansion	Quality Criteria
User engagement	The NSO is an innovative resource and undergoes constant development. Modern practice in innovation is to involve users, particularly in developing new functionality and resource design.	Lead-users are identified (frequent users, ones who communicate regularly with team) New users also identified via direct school contact (eg Academy Chain, Teaching School Alliance leads) User group has frequent contact eg when new resources are being developed Where possible user group members linked to Teaching School Alliances and Academy Chains to create 'cascade' possibilities User group includes representation from all 5

		<p>nations</p> <p>Costs for any work carried out by user group are covered</p> <p>Marketing and communications campaign to attract non-specialist users</p>
Curriculum coverage	Some comments in evaluation suggest a better fit with various curricula would be an improvement	<p>All teachers notes to show linkages with the various curricula and examination specifications</p> <p>Some activities might not have a direct link and should be indicated as such</p> <p>Curriculum should not restrict range of activities developed</p>
Curriculum resources and activities	<p>A strength of the current NSO offer. Novice users with no astronomy knowledge (eg some KS2 and KS3 teachers) might be put off by apparent need to engage with 'hard astronomy'</p> <p>Presentation of resources is as undersigned Word or PDF documents</p>	<p>Some activities and resources should focus on the wider science curriculum topics</p> <p>This new feature fore-fronted in marketing and communications campaign</p> <p>Resources professionally designed</p> <p>Use of diverse images of people</p> <p>All activities should have a wide range of teaching and learning approaches, so that all types of learner can feel that their interests, aspirations and self-image are being positively addressed</p> <p>Activities should support development of young people's awareness of careers in STEM</p> <p>Required background knowledge should be provided to support pupils and teachers who have not acquired the specific knowledge required by the activities</p> <p>One or more of the resources should be suitable for taking home, requiring pupils to carry out an activity with their family</p>
Marketing and communications	Some teachers seemed to find out about the NSO almost by chance.	Regular (eg termly) newsletter sent out to all STEMNET sub-regional contract holders and Science Learning Centres to include in their mailings to

		<p>schools and to feature on their web sites</p> <p>Articles for various periodicals (eg Education in Science, Primary Science Review) featuring the work of schools engaged with NSO</p> <p>Presence (eg running a workshop, exhibition stand) at national and regional ASE and Irish Science Teacher Association events</p> <p>Direct promotion to Academy Chains, Teaching School Alliances, and where present, local authority teacher groups (eg primary heads meetings, heads of science meetings)</p> <p>New recruits cite one of the above channels when signing up to website</p>
Training	Excellent on-line support available but some teachers would prefer face-to-face training	<p>User group contribute to design of 1 day training modules</p> <p>STEMNET and Science Learning Centres used to create on-going training programme</p> <p>Training modules differentiated to allow novice users with no astronomy experience to benefit</p> <p>Advanced training for current users</p> <p>Training events evaluated</p> <p>Training events involve current users as co-presenters</p>
Web site functionality	Like resources, a current strength of the NSO offer. However, some comments were made about functionality (eg suggestions for additional features)	<p>Functionality reviewed by user group</p> <p>Changes tested by user group prior to launch</p>

9 Project team

Ken Mannion – Director of the Centre Science Education
 Jon Carpenter, Research Fellow, Centre for Science Education

Mike Coldwell, Director of the Centre for Education and Inclusion Research

Contact details:

Ken Mannion – k.mannion@shu.ac.uk

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