



Report

**Final Report for the
National STEM Centre**

Evaluation of the European Space Education Resource Office

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Key findings

The National Foundation for Educational Research (NFER) has been commissioned by the National STEM Centre to evaluate the effectiveness and early impacts of the European Space Education Resource Office for the UK (ESERO-UK).

ESERO-UK aims to promote the use of space as a context for enriching science, technology, engineering and mathematics (STEM) teaching and learning in schools and colleges across the UK. The overarching aim of this research is to evaluate the effectiveness and early impacts of ESERO-UK on both teachers and stakeholders from universities and industry.

The research was conducted in four distinct phases, including:

- surveys of teachers and stakeholders
- collation of ongoing monitoring information from Space Ambassadors
- five in-depth case studies
- telephone interviews and email pro formas with ESERO-UK's national and regional partners and stakeholders.

Approaches to building and supporting a space education network

The ESERO-UK website

The ESERO-UK website has been operational since September 2010. Substantial efforts have been made to market and promote the ESERO-UK website, and this has led to a gradual

increase in usage over time. The website appears to be used by a growing number of unique users, as well as repeat visitors to the site.

National STEM Centre e-Library

The ESERO-UK collection within the National STEM Centre eLibrary currently consists of 223 resources. They are drawn from a wide variety of sources and are available in a range of formats. Work is ongoing to improve teachers' experiences of using the eLibrary (including, for example, the inclusion of teacher ratings and feedback).

Space Ambassador regional networks

Space Ambassadors have been involved in several **types of regional network** to date, including:

- strategic networks bringing together academics, industry and policy makers
- regional networks of education and training providers
- networks of schools
- virtual networks across geographically dispersed areas.

Space Ambassadors reported that they had been successful in building relationships with a **range of organisations**, including:

- professional bodies and organisations
- science centres, museums and galleries
- local authorities

- industrial organisations
- universities.

Such relationships were perceived to have been highly valuable in providing Space Ambassadors with a wider **forum for promoting ESERO-UK**. Space Ambassadors commonly integrated into existing networks, or collaborate with established organisations already proactive in the field of space education.

Space Ambassadors felt that the networks they had been involved with had been highly effective in enabling them to meet their goals. In particular, the networks were valuable in ensuring coherence and maximising impact across regions, and providing a collective voice for space education in negotiations with external parties. This was echoed by the views of network members, who reported that they had found their involvement in their networks valuable to their own work.

Space Ambassadors reported that, where they had contributed to existing networks or developed new ones, this had led to **substantial impacts on coherence within the space education community**.

Similarly, Space Ambassadors reported that membership of regional networks has enabled them to work with a **greater number of schools and colleges**. They also felt that the quality of space education provision has increased, becoming much more diverse and comprehensive as a result of the combined efforts of network members. This was also reported by network members themselves.

Several Space Ambassadors reported that, whilst it had been relatively straightforward to establish direct relationships with partner organisations, it

was considerably more challenging to establish wider regional **networks of stakeholders from a range of organisation types** due to their different work schedules, commitments and interests.

Several of the Space Ambassadors reported that it had been challenging to establish new regional networks due to a **lack of space industry partners in their local areas**. In some regions, it had also been a particular challenge to **establish networks within rural and remote areas**.

Approaches to enhancing and supporting STEM teaching and learning

Developing resources and good practice

Space Ambassadors and the national ESERO-UK office have supported the development of resources and good practice in a number of ways. Their activities have included **sourcing existing resources** for inclusion in the eLibrary and physical collection at the National STEM Centre, **submission of bids for funding** to develop resources, as well as the **proactive development of resources** in response to identified gaps in provision.

Space Ambassadors have also been involved in **the delivery of activities** which have yielded a considerable number of resources and good practice examples. Often, such activities have involved inputting to other existing programmes and initiatives.

Direct support of STEM teaching and learning

The activities explored during the case-study phase of this research exemplified a range of different approaches used to encourage, support and inspire teachers' use of space as a context for teaching and learning.

Light-touch support and guidance: This tended to be characterised by one-off activities suitable for teachers at all levels. The activities within this category tended to be relatively short, usually lasting not more than two hours. They most commonly focused on introducing a particular educational resource, or providing a general overview of a topical issue relating to space. Light-touch activities have sometimes been delivered on a standalone basis, but may also be situated within the context of a wider event.

Intensive CPD for teachers: Some of the support and guidance offered to teachers was much more in-depth, characterised by detailed exploration of a particular theme. These activities were targeted at teachers seeking to enhance their teaching skills at a more advanced level, which is a defining feature of this approach. However, unlike the light-touch support described above, this approach is more closely targeted towards specific groups of teachers (for example, secondary science teachers).

School-focused curriculum support: Support for teachers may also be characterised by ongoing, school-focused support and guidance. This type of activity is characterised by intensive, practical support for individual or a small group of schools, and provides specific curriculum support for teachers, alongside the direct

delivery of curriculum activities to students by experts. The approach is characterised by long-term planning, and appears to be highly suitable for schools with an interest in school-wide change.

Direct delivery to students: Approaches involving activities directly delivered to students could be integrated into any of the above strategies. Several of the Space Ambassadors have been involved in running **space and astronomy events, classes and courses** for young people.

Promoting ESERO-UK

ESERO-UK has been promoted widely to many local, national and international audiences by both regional Space Ambassadors, and the national ESERO-UK office. The ESERO-UK business manager, alongside Space Ambassadors, has presented widely at a variety of national **conferences and briefing events**. Promotion of ESERO-UK has also taken place via **stands, exhibitions and discussion** at public events.

Space Ambassadors have also promoted the work of ESERO-UK and space education more broadly, as a result of involvement in both **local and national media activities**. A number of dissemination opportunities have arisen due to Space Ambassadors' other professional responsibilities, which may provide them with access to a wider range of stakeholders, or to a broader geographical location.

A number of Space Ambassadors have also added events to the *What's On* section of the ESERO-UK website, and prepared articles for Space UK magazine and School Science Review. In Scotland,

regular *ESERO Scotland News* email updates have been issued to the network.

Other means of sharing resources and good practice have included **websites containing news about space and astronomy**, as well as resources for schools.

Experiences of, and impacts on, teachers, schools and students

The case studies, which exemplified a range of activities drawing upon the resources and support of ESERO-UK, revealed wide-ranging impacts on teachers, schools and students.

Personal impacts on teachers

Across all case studies, personal impacts on teachers were particularly strong. This included impacts on teachers’:

- awareness of space education resources and repertoire of ideas for using space as a context for their teaching
- confidence and skills to use space as a context for their teaching
- awareness of good practice.

Awareness of, and ideas for using, space education resources: The strongest impacts arising from the case studies appeared to relate to teachers’ increased awareness of, and ideas for using, space education resources. Across all case studies where teachers were surveyed, they reported that the activities had enabled them to develop **greater awareness of the range and scope** of space education resources. Similarly, they indicated that they had developed **ideas for using space**, and had

developed practical skills across a repertoire of teaching techniques.

Confidence and skills to use space education resources: When asked about their views prior to their involvement in the case studies, most teachers appeared to feel, relative to other areas, less **confident and skilled** in using the topic of space in their teaching. This may be attributable to teachers’ relative lack of previous professional development opportunities relating to space education. In all of the case studies where teachers were surveyed, positive impacts were observed in both of these respects, although, overall, they were more modest than in other areas.

In general, the greatest gains in confidence and skills levels were felt amongst primary school teachers. Possible explanations for this may include primary school teachers having taught fewer topics relating to space over the past year, and being less likely to have a specialist background in science than, for example, a secondary physics teacher.

The findings suggest that, given teachers’ concerns about their confidence and skills, as well the benefits in these areas realised by the case study activities, there may be a need to focus and develop activities to more closely meet the needs of teachers in terms of increasing their confidence and skills in using space in their teaching, and that **primary school teachers may particularly benefit from participating** in these types of activities.

Awareness of good practice: Across most of the case studies in which teachers were surveyed, the area in which the impact was less strong relative

to others (although still very positive) was an increase in teachers' **awareness of good practice** in teaching STEM subjects. This suggests that schools would welcome replicable models to support them in implementing good practice within their own schools.

Impacts on teachers' classroom practice

In general, the case studies showed very strong impacts in relation to developments in classroom practice. The case studies showed that impacts on teachers' *own* classroom practice were particularly strong. For example, teachers reported strongly that they would be able to apply their teaching to a range of real-world contexts, and increase the range of practical activities they offered to their students. This was closely followed by positive impacts on teachers' plans to cascade their learning further afield.

However, some teachers appeared to lose confidence in their ability to share their learning with other schools as time progressed. Therefore, the transfer of learning between schools may be an area in which teachers would benefit from additional, specific support.

Generally, impacts relating to teachers' awareness of space-related careers and their ability to explore these in the classroom also appeared to be lower than in other areas, suggesting that teachers would welcome further specific information about career routes and employment opportunities to enable them to guide their students more effectively. This echoes the findings of the early teacher surveys administered by Space Ambassadors in autumn 2010, which identified teachers'

awareness of careers in space as a particular priority.

Future use of space as a context for teaching: Across all case studies, there was a highly positive impact on the future likelihood of teachers and schools using space as a context for teaching and learning.

Whilst most teachers reported that they would be likely to use the kit as part of their national curriculum teaching, many reported that they would use it for a special event. Such special events included, for example, celebration events, cross-curricular space projects, science clubs, and space days/weeks.

Impacts on students

In those case studies where impacts on students were explored, participants observed considerable impacts on students'

- increased enjoyment of STEM subjects
- increased confidence in STEM subjects
- improved problem-solving and investigation skills
- increased interest in further STEM study
- development of transferable skills
- anecdotally, increased attainment in STEM and other subjects.

Broadly speaking, no individual case study resulted in more strongly reported impacts than another. The implications of this are two-fold. Firstly, this suggests that **there is a place for all types of support offered within the case studies**, ranging from general support for a wider audience of teachers to a much more focused, tailored and targeted approach towards smaller

groups. Secondly, it suggests that there are a range of routes by which these impacts can be brought about, indicating that ESERO-UK and associated delivery organisations should be **confident in the suitability of their flexible and responsive approach**.

Recommendations

ESERO-UK's key partners were asked to comment on key areas they would like to see developed in the future.

Overall, they felt that ESERO-UK had made good progress to date and were highly positive about the future of the organisation, they identified a number of areas that may benefit from further development. Many of these areas have already been recognised by the ESERO-UK team and are currently being addressed.

Their recommendations included:

- development of a deeper **understanding of who is providing space education**, and to find ways of supporting these organisations, to improve quality and share best practice
- further **dissemination and promotion of ESERO-UK** including, for example, good practice case studies and teacher vignettes on the ESERO-UK website
- establishment of **clearer protocols** for determining which resources should be published on the ESERO-UK website, so that teachers and others are clear about where to find the information they need
- development of more **rigorous procedures for quality assurance** of teacher resources in the eLibrary
- continued work with schools to **train them in the use of space education**

resources, in particular seeking out cost-effective ways of achieving this aim.

Additionally, findings from the research suggest that teachers would welcome further support in the following areas:

- development of the confidence and skills to use space in their teaching, with a specific focus on how to **cascade learning to their colleagues** within and between schools
- further **information and guidance about the range of career routes** and employment opportunities relating to space
- provision of **replicable models of good practice**, including real-life examples, which could be applied in their own classrooms.

ESERO-UK may also wish to consider new ways of supporting Space Ambassadors to engage with space industry partners at regional level, with a view to enhancing further the value and impact of existing educational networks.

Concluding comments

The findings highlight the many achievements of ESERO-UK in implementing a **range of effective strategies to promote and support space** as a context for STEM teaching and learning in schools.

It is evident that ESERO-UK plays an important role in supporting, adding value and drawing together existing space education provision. Likewise, the ESERO-UK team appears to be highly valued by their partners and stakeholders, as a means of consolidating and strengthening partnerships across the space and STEM education agenda.

1. Introduction

The National Foundation for Educational Research (NFER) has been commissioned by the National STEM Centre to evaluate the effectiveness and early impacts of the European Space Education Resource Office for the UK (ESERO-UK).

1.1 About ESERO-UK

ESERO-UK aims to promote the use of space as a context for enriching science, technology, engineering and mathematics (STEM) teaching and learning in schools and colleges across the UK. ESERO-UK was established by the European Space Agency (ESA) as part of a wider group of ESERO offices operating in several locations across Europe¹, and is jointly funded by the ESA and the Department for Education (DfE).

The key aims of ESERO-UK are to:

- promote the education resources of the ESA and UK space industry to schools and support teachers to use the resources more effectively
- bring coherence and coordination to the range of existing education resources and initiatives related to space
- develop and run a website to promote the wide range of space education resources and initiatives available to schools.

ESERO-UK is led by a business manager at the National STEM Centre in York, supported by a team of regional Space Ambassadors across the UK. The Space Ambassadors are responsible for promoting the work of ESERO-UK to teachers, and supporting them to make use of resources and draw on good practice to deliver space-related educational activities. ESERO-UK's operational remit does not necessarily involve setting up new activities, but rather supporting and adding value to a range of existing activities relating to space. Promotion and dissemination of teaching and learning resources is further supported by a website (www.esero.org.uk) and resources held at the National STEM Centre and National STEM Centre's eLibrary.

1.2 Aims of the research

The overarching aim of this research is to evaluate the effectiveness and early impacts of ESERO-UK on both teachers and stakeholders from universities and industry.

Specifically, the aims of the research are to evaluate the impact of ESERO-UK on teachers':

¹ In addition to ESERO-UK, there are ESEROs in Ireland, the Netherlands, Norway and Belgium.

- awareness of the resources, organisations and agencies which support schools to deliver space education activities
- use of resources via the National STEM Centre and National STEM Centre's eLibrary
- links with, and knowledge of career opportunities within, the UK space sector
- awareness of good practice in relation to using space as a context for teaching STEM subjects
- access to a coordinated database of space-related information.

In relation to stakeholders, the evaluation aims to explore their views on the:

- coordination and coherence of the space education network, and the information provided
- degree of duplication of information and provision, and awareness amongst providers of where duplication may exist
- identification of gaps in resources/provision.

1.3 Methods

The research was conducted in four distinct phases, including:

- baseline surveys of 175 teachers and 30 stakeholders administered by Space Ambassadors in autumn 2010 and spring 2011, to gauge their early experiences of working with ESERO-UK and explore emerging impacts
- collation of ongoing monitoring information regularly provided by Space Ambassadors to build an understanding of their approaches and activities related to their key performance indicators (KPIs)
- five in-depth case studies conducted in summer 2011, exploring a range of activities delivered under the ESERO-UK banner; methods included online and paper-based surveys and telephone interviews with teachers, and researcher attendance and observation at events
- telephone interviews and email pro formas with nine of ESERO-UK's national and regional partners and stakeholders in autumn 2011 and spring 2012 to gain their perspectives on progress to date and future developments.

1.4 About this report

This report draws findings from the final three phases of the research, and covers:

- ESERO-UK's approaches to building and supporting a space education network
- ESERO-UK's approaches to enhancing and supporting STEM teaching and learning
- experiences of, and impacts on, teachers, schools and students
- recommendations and concluding comments

The findings from the baseline surveys of teachers and stakeholders are presented in NFER's first interim report, submitted to the National STEM Centre in May 2011. Case-study findings are also presented in greater detail in NFER's second interim report, submitted to the National STEM Centre in December 2011.

2. Approaches to building and supporting a space education network

ESERO-UK's development of both national and regional networks of teachers and space education stakeholders is underpinned by the continued growth and development of the ESERO-UK website and resources contained within the National STEM Centre e-Library, and by regional networks established by the Space Ambassadors. Therefore, this section explores the approaches taken by the ESERO-UK office and its regional Space Ambassadors to build and support a space education network. In particular, it considers:

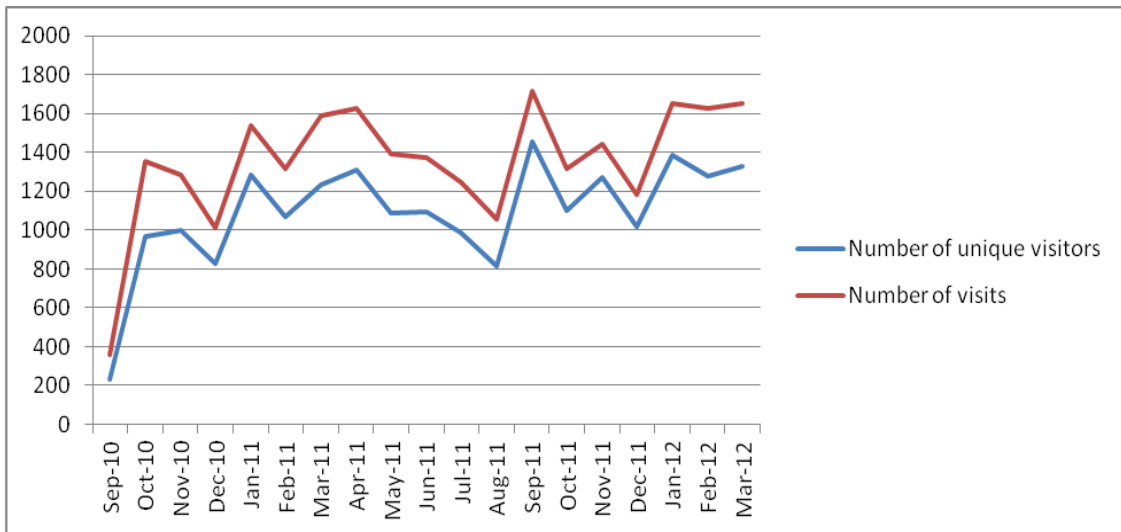
- the ESERO-UK website
- the National STEM Centre e-Library
- Space Ambassador regional networks.

Information is drawn from data provided by ESERO-UK's central team based at the National STEM Centre, regular progress reports produced by the Space Ambassadors, as well as interviews and pro formas completed by ESERO-UK's key partners and stakeholders.

2.1 The ESERO-UK website

The ESERO-UK website has been operational since 18th September 2010, and has received a total of 20,760 unique visitors between September 2010 and the end of March 2012. As presented in Figure 1, the total number of visits to the website has shown a gradual increase over time. Visits to the website appear to peak at the beginning of each school term, with lighter use during months containing a school holiday. For example, the website received a total of 1,716 visits during September 2011, compared to 1,056 the preceding month.

Figure 1 Number of visitors to the ESERO-UK website between September 2010 and March 2012



Source: ESERO-UK Website Editor

Figure 1 also shows that the number of *unique* visitors to the site has similarly increased. This indicates that the website is being accessed by a growing number of users, as well repeat visitors to the site.

Substantial efforts have been made to market and promote the ESERO-UK website, which have included links and banners to the ESERO-UK website added to the navigation bar of the National STEM Centre website and eLibrary, a ‘Features Carousel’ added to highlight news stories, eLibrary collection and resources on the National STEM Centre homepage, a National STEM Centre Twitter feed, and an online community area for space education discussion. Website monitoring data collated by ESERO-UK suggest that such approaches have been successful in directing traffic to the site. The National STEM Centre website is now, for example, ESERO-UK’s highest referring website (previously, this was the UK Space Agency website).

2.2 National STEM Centre e-Library

The ESERO-UK collection within the National STEM Centre eLibrary currently consists of 223 resources (an increase of 110 resources since early 2011), containing a total of 475 files. These resources are drawn from a wide variety of sources, including ESA, the National Aeronautics and Space Administration (NASA), National Schools’ Observatory, UK Space Agency, Our Space, European Southern Observatory, the Royal Astronomical Society (RAS) and video footage provider, Footagevault. Resources for the eLibrary have also been developed by the regional Space Ambassadors themselves. Resources are available in a number of formats, including pdf, video, flash animations and images.

As of March 2012, uptake of these resources appeared to be good. From a total of 11,317 page views in March 2012, there had been 2,192 downloads. This represents a conversion rate of 19.4 per cent. To further enable teachers to make use of the eLibrary collections, ESERO-UK are currently developing teacher ratings and feedback to help users gauge the usefulness of each resource, and its suitability for particular groups of children.

2.3 Space Ambassador regional networks

This section explores in-depth the Space Ambassadors' involvement in their regional networks. In particular, it considers:

- types of regional network
- membership of the regional networks
- effectiveness and impacts of the regional networks
- challenges and facilitating factors
- future developments.

Information is drawn from monitoring information provided by Space Ambassadors, as well as feedback from ESERO-UK's key partners and stakeholders.

2.3.1 Types of regional network

Space Ambassadors have been involved in several types of regional network to date, including:

- strategic networks bringing together academics, industry and policy makers
- regional networks of education and training providers, focused on continuing professional development (CPD)
- networks of schools
- virtual networks across geographically dispersed areas.

Strategic networks

Several Space Ambassadors have developed or become involved in **strategic networks**, bringing together academics, industry and policymakers to explore opportunities for developing space education. For example, the Space Ambassador in the North West and Shropshire has been involved in a network of eight key stakeholders including academics, space industry consultants, space outreach professionals and teachers. The aim of this network is to raise awareness of space as a context for teaching STEM subjects, and to facilitate sharing of experience and ideas.

CPD networks

Space Ambassadors have also been involved in **networks focusing on teacher CPD**. In Wales, the Space Ambassador has, following a series of meetings with the various regional co-ordinators of Careers Wales, started running a series of CPD sessions and school visits around Wales. Careers Wales provides the logistical support and communication with teachers, meaning that the Space Ambassador can focus primarily on delivery. Thus, the network makes the most of both partners' specialist expertise.

School networks

Whilst many Space Ambassadors have developed networks involving schools amongst other partners, some have established **school-specific networks**. In Wales, the establishment of a schools network based around the provision of the Edexcel GCSE Astronomy qualification has been very successful, with the pilot project at Glyncoed Comprehensive (one of NFER's case studies) being expanded to two more schools in the area. In addition, seven other schools across Wales have been linked in to the GCSE *Astro Masterclasses* programme run at the University of Glamorgan.

Virtual networks

Several Space Ambassadors have established **virtual networks**, due to geographical and time constraints of network members. For example, the Space Ambassador for the Midlands and South East has made ongoing use of previously established virtual regional networks for the dissemination of ESERO-UK and National Space Academy activities. This has included organisations such as the Institute of Physics (IoP), RSC, the East Midlands Science Learning Centre network, the *Leading Space Schools* network, the Science and Technology Facilities Council (STFC), the Science, Technology, Engineering and Mathematics Network (STEMNET) and local authority networks.

2.3.2 Membership of the regional networks

Space Ambassadors reported that they had been successful in building relationships with a range of organisation types, including:

- **professional bodies and organisations**, such as IoP, STEMNET, and the Royal Society of Chemistry (RSC)
- **science centres, museums and galleries**, such as the Centre for Life in Newcastle and Techniquest Science Discovery Centre in Wales
- **local authorities**, in particular school science advisors and educational development services
- **industrial organisations**
- **universities**.

ESERO-UK's Scotland Network: an example of a new network

The ESERO-UK Scotland network is made up of around 15 organisations across Scotland and is chaired by the Space Ambassador for Scotland. Membership organisations include university science and engineering departments, STEMNET, IoP, the Association for Science Education (ASE), the Scottish Schools Education Research Centre (SSERC), The Royal Observatory, science centres and others.

Members of the network became involved through projects they had previously been involved in with the Space Ambassador. They attend face-to-face meetings 2-3 times per year, and share emails where appropriate. Smaller groups get together to plan specific events as required. The network also organises one-off meetings, for example to bring together interested parties to support the development of astronomy and cosmology content in new courses in schools.

The ESERO Scotland network is central to what we have, and will, achieve. [Members] provide instant access to informed opinion from relevant space education providers and teacher organisations – to share information and to develop and deliver new activities.

Space Ambassador

A key benefit of the ESERO-UK network is opportunity has been to test out new ideas or opportunities. Most of these ideas are initiated by the Space Ambassador, and others are initiated by network members as well as third parties who are referred to the network as a key forum for space education.

Such relationships were perceived to have been highly valuable in providing Space Ambassadors with a wider **forum for promoting ESERO-UK**, and for disseminating resources and good practice to schools. Space Ambassadors felt that some of the relationships were newly developed, initiated and led by themselves. However, they more commonly reported that they had joined or developed existing space education networks. Space Ambassadors reported that integrating into existing networks, or collaborating with established organisations already proactive in the field of space education, was a more efficient, cost-effective and powerful approach to giving ESERO-UK a voice amongst space and education providers.

Rather than establishing a new, specialist ESERO-UK network with an emphasis on astronomy/space, I have chosen to work within the existing networks, which typically consist of the same people.

Space Ambassador

Examples of such existing networks include:

- **Y|E|S net**, an organisation based in Yorkshire and the Humber, which aims to maximise the educational value of space and develop the best ways of using space activity for learning
- the **Dark Sky Scotland steering group**, a partnership led by the Royal Observatory Edinburgh

- **STEMNET**, through its local contract-holder in a number of regions
- the **National Space Academy Network** established in February as an expansion of the previous Regional Space Academy project team
- the **North West Science Alliance** (NWSA)
- the **IoP Teacher Network**.

Although not all are exclusively space-focussed, Space Ambassadors felt that such networks already bring together most of the important stakeholders. Additionally, Space Ambassadors felt that membership of broader networks give the opportunity to disseminate ESERO-UK's activities to a wider audience (i.e. those who are not already directly involved in space education).

Y|E|S net: an example of ESERO-UK's contribution to an existing network

Y|E|S net is a network of providers of space education in the Yorkshire region. Established prior to the formation of ESERO-UK, Y|E|S net is coordinated by Space Connections and more recently supported by ESERO-UK. Y|E|S net aims to promote STEM and believes that space activity is a key way to attract and motivate young people.

The network is made up of many different educational and industrial providers, including the Aviation Academy, Bradford Robotic Telescope, IoP, Leeds Museums and Galleries, the Sheffield Astronomical Society, Space Connections, STEMNET, the University of York and the Yorkshire Air Museum.

The Space Ambassador for Yorkshire and the Humber reported that ESERO-UK confirmed and strengthened Y|E|S net's existing links to the European Space Agency and the UK Space Agency. Conversely, the network has also been beneficial to ESERO-UK, offering a good mechanism for promoting ESERO-UK and raising awareness of ESERO-UK's resources and activities across the region. New members such as local astronomical societies are being recruited through Dark Sky and other astronomical developments.

2.3.3 Effectiveness of the networks

Space Ambassadors felt that the networks they had been involved with had been highly effective in enabling them to meet their goals. In particular, the networks were valuable in ensuring coherence and maximising impact across regions, and providing a collective voice for space education, encompassing a wide range of professionals.

Existing networks have been invaluable as... a means of reaching teachers and other educators who are not already using space as a significant teaching resource (who must, obviously, be a priority audience for ESERO-UK).

Space Ambassador

Real enthusiasm for space content has come from unexpected quarters such as literacy advisers, public health professionals and technology teachers.

Space Ambassador

This was echoed by the views of network members, who reported that they had found their involvement in their networks valuable to their own work. For example, in Scotland, the Space Ambassador has met with the network of Scottish Science Festivals and the Highlands and Islands Science Festivals to encourage public and schools/teacher-aimed events, which has been appreciated and taken up by a number of festivals.

I've found [the Space Ambassador] enthusiastic and knowledgeable, who thinks creatively about how to engage with new audiences.

Network member

[The Space Ambassador] has chiefly [encouraged involvement in the regional network] by running and being prepared to contribute to a number of highly relevant CPD and training events. These bring members together with a common purpose.

Network member

[The Space Ambassador] regularly gets in touch, introducing us to other members, and suggesting ways we might work together.

Network member

Network members also reported that they valued opportunities to work collaboratively with partners. Organisations were, in general, very keen to collaborate and felt that ESERO-UK has helped to facilitate this. They reported that the input of Space Ambassadors had enriched their experiences of delivering space-related education, provided them with expert advice and advice about funding sources, and enabled them to meet with likeminded professionals.

The ESERO Scotland network has been useful in providing a focal point for space-related activities and education. This in turn has helped me to encourage science festivals (particularly in rural areas with darker skies) to plan their activities on a more collective basis, and to allow presenters to be shared.

Network member

We are very keen to collaborate, and [the Space Ambassador's] support has helped us to do so. For example, we deliver professional CPD through collaborative partnerships, and [the Space Ambassador's] involvement has helped enrich the programme with stargazing sessions delivered by experts.

Network member

[The Space Ambassador] always makes himself available at the brainstorming sessions of our planetarium shows and acts in an advisory capacity throughout the process. [He] ensures the content of our planetarium shows is correct and up to date. He checks all of the scripts and checks the footage. This expert advice

validates our shows in terms of content.

Network member

Being a lone trader it can be very difficult to make the right connections within big institutions however [the Space Ambassador] has introduced me to many individuals and institutions that has certainly helped me with my work.

Network member

2.3.4 Impacts on coherence in the space education community

Space Ambassadors reported that, where they had contributed to existing networks or developed new ones, this had led to **substantial impacts on coherence within the space education community**. For example, the Space Ambassador for Yorkshire and the Humber reported that the existence of Y|E|S net as a unique regional space-related education network had provided the necessary forum for collaboration to submit successful applications for funding, and in attracting science to the area (e.g. the British Science Festival, held in Bradford in 2011).

Similarly, the Space Ambassador for the East Midlands and the South East reported that the work of the National Space Academy had ‘successfully dovetailed with the work of other Space Ambassadors to ensure minimal repetition and maximum mutual support’. Examples of this included **joint delivery of masterclasses, careers events and CPD programmes** with the Space Ambassador for the South West, and delivery of the **Galileo teacher CPD programmes** alongside the Space Ambassador for Wales.

2.3.5 Impacts on Space Ambassadors’ ability to support schools and colleges

Space Ambassadors reported that membership of regional networks has enabled them to work with a **greater number of schools and colleges**. They felt that the quality of space education provision has also increased, becoming much more diverse and comprehensive as a result of the combined efforts of network members. This was also reported by network members themselves, who valued the expertise of Space Ambassadors when developing new activities and programmes, and as well as the collective input and experience of the wider network.

The main beneficiaries, however, are users such as teachers, schools and pupils. Working together we can offer them a much better deal, a more comprehensive and diverse offering, than we would be able to achieve by working individually... events such as these become much more collaborative and coherent when the presenters already know each other well; they can make effective cross-referencing and can complement each other rather than compete. The quality of the event is enhanced in these ways.

Space Ambassador

One outcome of a teacher placement day on the Faulkes Telescope was to enthuse one particular teacher so much that she introduced the subject in her school and

now runs a very successful course for students.

Network member

Space Ambassadors felt that they had been able to develop **greater awareness of opportunities** for students and teachers as well as greater **uptake of CPD and careers events**. This was echoed by network members, who reported that they had observed an **increase in awareness and demand for space-related activities and training events**, and a resulting increase in the delivery of such activities.

Feedback shows that delegates have greatly valued ESERO-UK's input [alongside other key partners] into their teaching and they have adopted the materials and practices they have been shown.

Network member

All the placements we have arranged with [the Space Ambassador's team] have been excellent and the teachers involved in the placements have become enthused with the subject and keen to develop the subject in the base school.

Network member

Further exploration of the impacts on teachers, schools and pupils is detailed in section 4.

2.3.6 Challenges and facilitating factors

Several Space Ambassadors reported that, whilst it had been relatively straightforward to establish direct relationships with partner organisations, it was considerably more challenging to establish wider regional **networks of stakeholders from a range of organisation types** due to their different work schedules, commitments and interests (for example, to ensure that engagement was as meaningful for individuals within the network as it was for larger institutions). This was echoed by members of the regional networks, who reported that they sometimes had to miss meetings due to conflicting calendar commitments.

Whilst in some cases this problem was insurmountable, to overcome this challenge several Space Ambassadors reported that they had successfully established 'virtual' networks of space education professionals, enabling communication to take place electronically rather than face-to-face. In other instances, network members reported that their Space Ambassador had been proactive in seeking their input to feed into discussion if they were unable to attend, as well as following up face-to-face meetings with telephone and email updates. More broadly, network members praised the personal commitment of the Space Ambassadors as critical to the success of the networks. This included regular contact and excellent support, and the ability to cultivate a network that is diverse and sensitive to one another's skill sets.

The only challenge has been having to miss a couple of meetings... I've overcome this by emailing [the Space Ambassador] an update to feed into the discussion. Phone/email discussions afterwards updated me on the outcome of the meeting.

Network member

The types of regional networks emerging were, to a great extent, characterised by their specific local context. Several of the Space Ambassadors reported that it had been challenging to establish new regional networks due to a **lack of space industry partners in their local areas**. Whilst Space Ambassadors were still able to establish networks with academic and educational partners, these were not considered to be as meaningful as if industry was also involved. In addition, it was felt that there were already strong academic and educational networks in some regions. Therefore, additional networks were perceived to be counter-productive.

The lack of any appreciable 'space industry' in [the region] means that there is no industrial base to engage with.

Space Ambassador

The main source of the problems encountered in setting up networks was due to the dearth of significant space industry in [the region]. There are no companies for whom space is a major focus and those that are involved only have a small stake. Therefore it has been impossible to find anyone in industry who is willing to spare the time to support a regional network.

Space Ambassador

For networks involving schools, Space Ambassadors identified that an important issue relates to the identification of **key themes and learning outcomes** that justify teachers leaving the classroom. Time is also a considerable factor when working with schools: one Space Ambassador reported that several teachers had asked them to film practical sessions so they can share ideas with their colleagues more easily.

In some regions, it had been a particular challenge to **establish networks within rural and remote areas**. In Wales for example, the Space Ambassador's approach was tailored to reflect this, and work was underway to develop existing activities (for instance, those delivered by the National Astronomy Meeting in Llandudno), to broaden their appeal to rural audiences and to be inclusive of Welsh language speakers. In other areas, such as the North West and Shropshire, the type and nature of its regional networks had been shaped by difficulties engaging with industrial stakeholders as space industry in the region is relatively small-scale. Network members in Scotland reported that they greatly appreciated their Space Ambassador's efforts to engage with audiences across a broad geographical area, and to ensure that the activities offered are as useful and relevant to schools in remote areas as they are to urban schools.

Any Scottish network has to be as useful to someone in Orkney as in Glasgow... [the Space Ambassador's] team has been willing and able to travel to distant shores

and to come along to our residential CPD events that bring teachers from all over Scotland together.

Network member

In other areas, Space Ambassadors felt that their ability to initiate networks had been limited by a reduction in regional sources of support and funding, such as the Regional Development Agencies (RDAs).

With the demise of [the RDA] there is a lack of the regional direction and consultation that came from the former regional economic strategy. The common purposes we were formerly working towards are no longer so apparent. The demise of the regional funding which energised partnership has thrown organisations back into more individual and perhaps more competitive stances.

Space Ambassador

Space Ambassadors reported that a considerable facilitating factor in ensuring the success of their involvement in networks has been the ability to **capitalise on pre-existing contacts within the education and outreach community** through their other roles, and to make use of existing networks with established databases of schools and industrial organisations.

My work prior to the ESERO-UK role has allowed me to build an extensive network of contacts, which has proven invaluable in targeting schools, teachers etc. across the region.

Space Ambassador

However, Space Ambassadors also noted that, whilst integrating into existing networks has brought considerable benefits, a key challenge with the approach is that they are reliant on personnel in other organisations to determine the direction and focus of such networks. Therefore, they are subject to external factors beyond their direct control.

2.3.7 Future development of regional networks

The feedback provided by network members was resoundingly positive, who reported that they would simply welcome 'more of the same', building upon the links that have been established to date and capitalising on current public interest in physics and astronomy.

[We would like] more of the same. This is a time of change in... education, and physics and astronomy are not only featuring more than ever in courses, they have a higher profile in the public consciousness. We need to maintain this and will best do so by bringing everyone who can contribute to the table.

Network member

It would be good to continue the work, especially networking and facilitation of contact with potential collaborators, to make the most of existing resources.

Provision of associated funding – even if only in small amounts – would help make developments sustainable.

Network member

Space Ambassadors plan to further develop existing networks, including extending the reach of their activities in their regions (for example, working with academic research groups and universities), developing contacts and networks in new areas (e.g. space robotics research), increasing the number of school visits and teacher training, sourcing new networks with good track records of effectiveness, and increasing the sense of common purpose amongst networks. This might include, for example, developing a clearer topical focus that will be of interest and benefit to all members of the network (for example, business-related topics to help members with management issues within the current economic environment).

3. Approaches to enhancing and supporting STEM teaching and learning

This section considers ESERO-UK's approaches to enhancing and supporting STEM teaching and learning in schools. In particular, it explores how ESERO-UK has:

- developed resources and good practice
- directly supported STEM teaching and learning
- promoted itself and its work.

The chapter draws upon findings from Space Ambassador reports and five in-depth case studies conducted in summer 2011. Further detail of the case studies is provided in section 4.

3.1 Developing resources and good practice

Space Ambassadors and the national ESERO-UK office have supported the development of resources and good practice in a number of ways throughout the evaluation period. Their activities have included **sourcing existing resources** for inclusion in the eLibrary and physical collection at the National STEM Centre, **submission of bids for funding** to develop resources (nationally, a proposal has been submitted to the UK Space Agency to develop resources for use in primary schools based on the space exploration project, *Aurora*), as well as the **proactive development of resources** in response to identified gaps in provision, which are of value to the National STEM Centre eLibrary.

Examples of resources include the Space Ambassador for the East Midlands and the South East developing a series of YouTube videos using space as a context, filmed for the Specialist Schools and Academies Trust (SSAT) Triple Science Lead Practitioner Programme. In Wales, the Space Ambassador is involved in the ongoing development of astronomy resources as part of the new *Astronomy e-labs* project, funded by the University of Glamorgan, and online resources funded by STFC and RAS, both of which will include materials suitable for the Edexcel GCSE Astronomy curriculum.

Space Ambassadors have also been involved in **the delivery of activities** which have yielded a considerable number of resources and good practice examples. Often, such activities have involved inputting to other existing programmes and initiatives. In Scotland, online and video resources about *Deep Space* have been produced to coincide with a one-day event organised by the Association for Science Education (ASE) Scotland and IoP Scotland. Similarly, in the South West, the Space Ambassador has been directly involved in delivering a trial *Train Like an Astronaut* event with key stage 4 students. Likewise, the Space Ambassador for Wales has

been heavily involved in delivering the *Galileo Teacher Training Programme*, which provides free resources, software and data for schools.

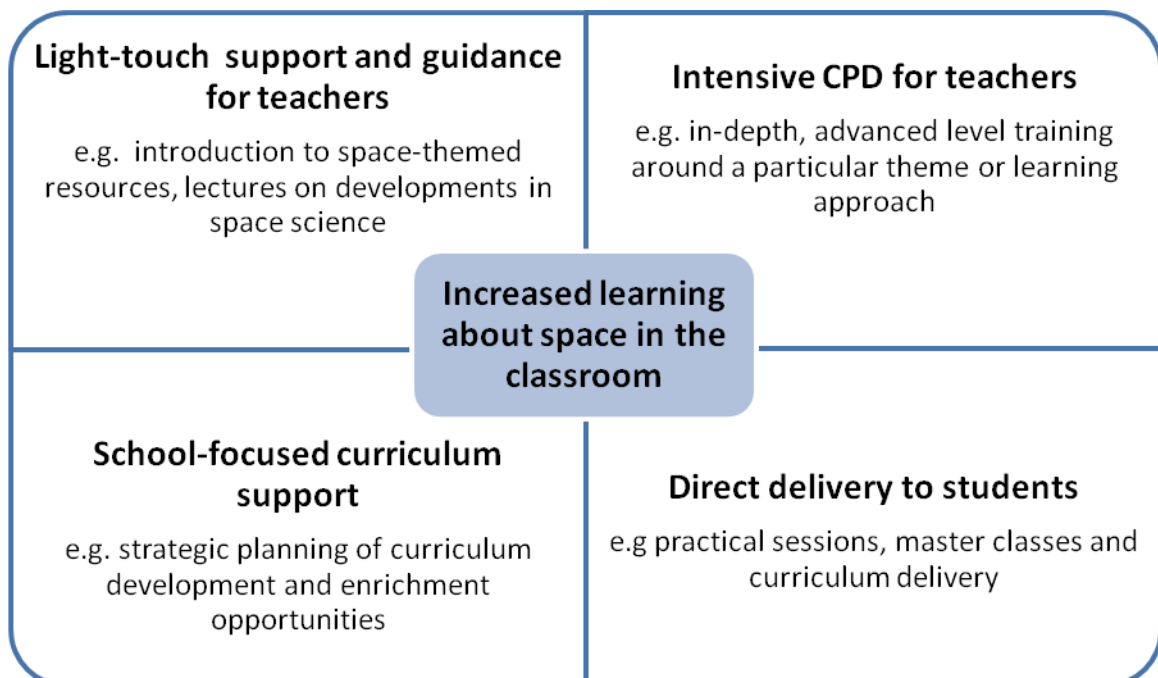
ESERO-UK's existing resources are currently undergoing a process of teacher review. It is envisaged that this will help teachers to find and select resources appropriate to their needs, and to ensure that available resources are relevant to teachers. Space Ambassadors are, therefore, keen to see the results of this so that further resources may be developed.

3.2 Direct support of STEM teaching and learning

The activities explored during the case-study phase of this research exemplify a range of different approaches used to encourage, support and inspire teachers' use of space as a context for teaching and learning. In this section, these approaches are taken together with feedback from Space Ambassadors to explore the ways in which ESERO-UK is enhancing and supporting STEM teaching and learning.

ESERO-UK's approaches fall into four main categories, detailed in Figure 2. Each of these approaches is characterised by particular features which provide a useful framework for our understanding of the activities offered by, and in association with, ESERO-UK.

Figure 2: Approaches to using space as a context for STEM teaching



3.2.1 Light-touch support and guidance

The 'light-touch' support and guidance offered to teachers and members of the general public tended to be characterised by one-off activities suitable for teachers at all levels. It is important to note that 'light-touch' in this context is used to describe the

type of support offered to teachers, rather than the role of ESERO-UK. The activities within this category have tended to be relatively short, usually lasting not more than two hours. They have most commonly focused on introducing a particular educational resource, or providing a general overview of a topical issue relating to space. The case study detailing promotion of the ISS Education Kit is an example of such a light-touch activity, as are the individual lectures delivered by space scientists at the ESERO-UK Space Education Day.

Promotion of the International Space Station (ISS) Education Kit

In the North East of England, a number of activities have been run to promote space resources to primary schools. This case study focused on one of the key resources being promoted, the International Space Station (ISS) Education Kit for primary schools. The ISS Education Kit is an educational resource package for teachers produced by the European Space Agency (ESA).

The ISS Education Kit provides teachers with a range of ideas on how to use the International Space Station as a theme for teaching and learning across a range of curriculum areas. The resource contains four programmes of study exploring life in space, and what it is like to live and work at the International Space Station. Across the North East, in-school training events have been held, as have introductory workshops at events such as network meetings for science coordinators and the North East Primary Science Conference.

Promotion of this resource across the region has been coordinated and overseen by the Space Ambassador for the North East, who also delivered some of the sessions. Teachers were highly positive about their experience of being introduced to the resource, and one reported that the ISS Education Kit meets a gap in the market as similar resources are hard to find.

Light-touch activities have sometimes been delivered on a standalone basis, but may also be situated within the context of a wider event. For example, whilst the *individual sessions* delivered within ESERO-UK's Space Education Day may be understood as 'light-touch' activities, they were situated within a much broader and more extensive programme of teacher engagement throughout the event as a whole.

ESERO-UK Space Education Day

As part of the inaugural UK Space Conference in July 2011, ESERO-UK ran a dedicated Space Education Day. Specifically designed for primary and secondary school teachers, the event was free to attend and included activities such as:

- lectures delivered by space science professionals, on themes such as: astrobiology and the hunt for alien life; living in the sun's atmosphere; the search for life on Mars; and space science, conspiracy theories and science education
- workshops focused on particular space education resources such as: using space resources in primary schools; the Faulkes Telescope and the National Schools Observatory; and the National Space Centre
- workshops focused on curriculum design, such as: the use of science, maths and geography in the transition between key stage 2 and key stage 3; and re-designing Year 8 science
- workshops focused on building networks and cascading information, such as the IoP teacher network, and careers in space.

The event was attended by approximately 100 delegates (46 of whom participated in the research) from a range of teaching disciplines at both primary and secondary level.

Space Ambassadors also reported that they had undertaken a considerable amount of 'light touch' support and guidance at **existing STEM activities and events** (for example, the Big Bang Fair and conferences held by the ASE). They had also used such light-touch approaches to **disseminate resources to audiences outside of space or STEM education**. For example, in the North West and Shropshire, there has been active engagement with the arts community, with amateur astronomers, and with the general public. The Space Ambassador in this region is currently working with an early music orchestra to bring together the music and astronomy of William Herschel, which will be incorporated into an educational resource pack.

3.2.2 Intensive CPD for teachers

By contrast, some of the support and guidance offered to teachers was much more in-depth, characterised by detailed exploration of a particular theme. An example from the case studies is the *Ticks the Box* teacher training day delivered at the National Science Learning Centre (NSLC).

Ticks the Box: A teacher training day

Ticks the Box was a teacher training day held at the National STEM Centre and delivered by Space Connections. Space Connections is a national organisation based in West Yorkshire, which delivers resources for teachers relating to space, and is the organisation that employs ESERO-UK's Space Ambassador for Yorkshire and the Humber. The teacher training day was attended by 18 primary teachers, who participated in a range of talks and activities including:

- an introduction to practical activities for primary schools, focusing on using the context of a space mission to discover if life exists on Mars
- a rocket building and launch activity
- an introduction to the Bradford Robotic Telescope
- an opportunity to experiment with a box of classroom activities, which can be easily implemented in the classroom.

Teachers were introduced to ESERO-UK throughout the day, including its STEM library and eLibrary resources. ESERO-UK also provided support to Space Connections in organising the event, via the business manager based at the National STEM Centre, as well as the region's Space Ambassador.

Another of the case studies, *Space as a context for teaching science*, focused around the development of the James Webb Space Telescope (JWST), is an example of this type of intensive CPD.

Space as a context for teaching science: An intensive teacher CPD course

This two-part, intensive CPD course was aimed at secondary science teachers, supported by an ENTHUSE funding grant and based around the development of the JWST. Topics covered during the course included school spectroscopy, the use of space-related instruments (e.g. JWST's Mid Infrared Instrument, or MIRI), the use of materials in space, rocketry and school astronomy.

The first part of the course took place at the Royal Observatory, Edinburgh (ROE) in June 2011, and included laboratory visits, practical techniques and teaching ideas, and the development of innovative learning materials. Participants produced an action plan for implementation after the course, and shared their experiences at the second part of the course, which took place at the National Science Learning Centre (NSLC) in York in October 2011. The course was organised by a team of professionals including the Space Ambassador for Scotland, the Royal Observatory Edinburgh (ROE) and NSLC staff. Sessions were also delivered by Space Ambassadors from a number of regions. ESERO-UK also provided support in advertising and promoting the course via its website, and provided further introduction to the range of services it offers during the second part of the course.

Both of these activities were targeted at teachers seeking to enhance their teaching skills at a more advanced level, which is a defining feature of this approach. However, unlike the light-touch support described above, this approach is more closely targeted towards specific groups of teachers (for example, secondary science teachers). Given the in-depth focus of this approach, at an individual level these activities are unlikely to hold a universal appeal for teachers. Intensive CPD activities can, as with light-touch support, be delivered as a standalone event, but may also include follow-up or action planning to help teachers act on what they have learnt (as demonstrated in *Space as a context for teaching science*).

3.2.3 School-focused curriculum support

Support for teachers may also be characterised by ongoing, school-focused support and guidance (e.g. GCSE Astronomy at Glyncoed Comprehensive School). This type of activity is characterised by intensive, practical support for individual or a small group of schools, and provides specific curriculum support for teachers, alongside the direct delivery of curriculum activities to students by experts. The approach is characterised by long-term planning, and appears to be highly suitable for schools with an interest in school-wide change.

GCSE Astronomy at Glyncoed Comprehensive School

This case study focused on the delivery of GCSE Astronomy at Glyncoed Comprehensive School in Blaenau Gwent Local Education Authority (LEA), Wales. The course was planned and delivered by the school in collaboration with the Director of Education at the Faulkes Telescope Project, and ran during the academic year 2010/11.

Approximately 30 female students, aged between 13 and 15, were invited to participate in the programme. The course was delivered on an extra-curricular basis, and so students' own motivation was perceived to be critical to their successful completion of the course. Teaching methods comprised a variety of approaches, including after school sessions, residential weekend sessions, master classes, observation coursework and revision and consolidation sessions.

3.2.4 Direct delivery to students

Approaches involving activities directly delivered to students could be integrated into any of the above strategies. Several of the Space Ambassadors have been involved in running **space and astronomy events, classes and courses** for young people. Within the case studies, for example, the introduction of GCSE Astronomy at Glyncoed Comprehensive School involved direct delivery to students as part of school-focused curriculum support. However, practical sessions to students were also included in a session delivered as part of the ESERO-UK Space Education Day, which is an example of more light-touch support.

Space Ambassadors in Wales, the South West and the North West and Shropshire have also been involved in running a series of four GCSE Astronomy master classes throughout March and April 2011. The workshops, funded by Beacons for Public Engagement Wales, have attracted approximately 200 students. Additionally, in the East Midlands and the South East, student master classes have been held at the National Space Centre with 1,650 students attending from 75 schools, and students have also been targeted via careers events to develop their knowledge of, and career pathways within, the space sector. In Scotland, pupils from 17 schools have visited the Royal Observatory Edinburgh, in their capacity as prize-winners at the Scottish Space School. The Space Ambassador for the North West of England and Shropshire has delivered seven short workshops for a total of 500 pupils in Key Stages 2, 3 and 5, using space as a stimulus for enhancing their appreciation of science. The Space Ambassador for Wales has delivered half- and full-day student masterclasses, student lectures and presentations, and careers events.

3.3 Promoting ESERO-UK

ESERO-UK has been promoted widely to many local, national and international audiences by both regional Space Ambassadors, and the national ESERO-UK office. The ESERO-UK business manager, alongside Space Ambassadors, has presented widely at a variety of national **conferences and briefing events**, including the ASE

National Conference, the Big Bang Fair, the National Science Learning Centre (NSLC) STEM Cohesion Conference, the Learning and Skills Improvement Service (LSIS) STEM Conference, the University of Birmingham/Institute of Physics Teacher Conference, Parliamentary Space Committee, and the Engaging Wales conference in Cardiff.

Promotion of ESERO-UK has also taken place via **stands, exhibitions and discussion** at public events (for example, AstroFest, ASE National Conference, British Science Festival, UKAYRoC and the Appleton Space Conference), and **teacher CPD events**: internationally, the Space Ambassador for East Midlands and the South East has been involved in the delivery of teacher master classes at the ESA Human Spaceflight 2010 Teacher Conference (ESTEC), and Space Ambassadors have been involved in a wide range of national and local CPD events.

Space Ambassadors have also promoted the work of ESERO-UK and space education more broadly, as a result of involvement in both **local and national media activities**. This has included regional radio and television appearances, as well as the provision of advice, observations and images for the BBC's *Stargazing Live* programmes and support for the BBC Education Department. Several Space Ambassadors have also been involved in planning major outreach events associated with the *BBC Stargazing Live* broadcast programmes. Some of these events have been targeted at the public (e.g. live observation), and others have been targeted at teachers (e.g. *Wales HE STEM teacher training event* in Swansea).

It is valuable to note that a wider number of dissemination opportunities arise due to Space Ambassadors' other professional responsibilities, which may provide them with access to a wider range of stakeholders, or to a broader geographical location. For example, in his capacity as Director of the International Planetarium Society, the Space Ambassador for Northern Ireland has been able to promote ESERO-UK activities at events in Seoul, Korea, and Rio de Janeiro, using ESERO-UK as a model to discuss the benefits of the STEM agenda on a world scale.

Space Ambassadors in Wales and Northern Ireland have also adopted innovative approaches to **dissemination to meet local needs**. For example, the Space Ambassador in Wales is working with the Wales Video Network to deliver video-conference talks and workshops to schools in hard to reach areas across Wales. In Northern Ireland, where transport costs can be a considerable barrier to, for example, visits to educational sites, the Space Ambassador is working alongside partners in ESERO Ireland to deliver teacher training across both Ireland and Northern Ireland.

A number of Space Ambassadors have also added events to the *What's On* section of the ESERO-UK website, and prepared articles for Space UK magazine and School Science Review. In Scotland, regular *ESERO Scotland News* email updates have been issued to the network. Other means of sharing resources and good practice have included **websites containing news about space and astronomy**, as well as resources for schools.

4. Experiences of, and impacts on, teachers, schools and students

This section draws on the findings of five case studies conducted in summer 2011 to explore teachers, schools and students' experiences of working with ESERO-UK, and the impacts arising from this. Whilst the activities included as case studies predominantly focused on teachers, reflecting the wide range of support ESERO-UK provides for teaching professionals, the case studies also provided an opportunity to tentatively explore wider impacts on schools and students. Such impacts were wide-ranging, and included:

- **personal impacts on teachers**, including their awareness of space education resources, their ideas for using space as a context for their teaching, and their confidence and skills to do so
- **impacts on teachers' classroom practice**, including their use of real-world contexts and practical activities, and plans to cascade their learning to other teachers
- **impacts on students**, including their confidence, skills and achievement.

4.1 About the case studies

The five case studies included in this research were selected by NFER from a list of suggestions provided by ESERO-UK's business manager and team of regional Space Ambassadors, who were asked to provide examples of activities which drew upon the resources and support of ESERO-UK. The case-study sample was selected to reflect the broad nature of the support ESERO-UK provides, and the different ways in which it strives to reach its target audiences.

As detailed in section 1.1, in addition to supporting teachers directly, ESERO-UK also aims to promote and bring coherence to the range of existing resources relating to space. Therefore, the case-study sample was selected to include activities delivered by independent organisations that had received support from ESERO-UK, as well as activities directly delivered by the ESERO-UK team. ESERO-UK's involvement in the case studies varied from having a major role in facilitating and delivering activities, to a more supportive background role. However, all case studies had in common the aim to improve, increase or enhance the use of space as a context for STEM teaching and learning, drawing on the combined expertise of ESERO-UK and its partners.

The case studies comprised:

- the **ESERO-UK Space Education Day**, a national educational conference for teachers which ran alongside the inaugural UK Space Conference at Warwick University and was organised by ESERO-UK

- promotion of the **International Space Station (ISS) Education Kit**, a resource package for primary school teachers. This introduction and promotion of this kit was coordinated and overseen by the Space Ambassador for the North East
- **Space as a Context for Teaching Science**, an intensive continuous professional development (CPD) course for secondary school teachers, delivered in Edinburgh and York. The course was organised by a team of professionals including the Space Ambassador for Scotland, and also included delivery of sessions by ambassadors from other regions
- **Ticks the Box, a space-themed training day** for primary school teachers in Yorkshire and the Humber, held at the National Science Learning Centre (NSLC), which was promoted and facilitated by ESERO-UK
- the introduction of **GCSE Astronomy for female students** at Glyncoed Comprehensive School in Wales, supported by the Space Ambassador for Wales.

4.2 Personal impacts on teachers

Across all case studies, personal impacts on teachers were particularly strong. This included impacts on teachers’:

- awareness of space education resources and repertoire of ideas for using space as a context for their teaching
- confidence and skills to use space as a context for their teaching
- awareness of good practice.

4.2.1 Awareness of, and ideas for using, space education resources

The strongest impacts arising from the case studies appeared to relate to teachers’ increased awareness of, and ideas for using, space education resources. Across all case studies where teachers were surveyed, they reported that the activities had enabled them to develop **greater awareness of the range and scope** of space education resources. Similarly, they indicated that they had developed **ideas for using space**, and had developed practical skills across a repertoire of teaching techniques.

For example, teachers who attended the ESERO-UK Space Education Day were overwhelmingly positive about their experiences of attending the event. Teachers reported that they found the ESERO-UK Space Education Day to be particularly valuable in providing:

- a forum to share ideas and to establish contacts with teachers in other schools
- demonstrations of practical activities with pupils, which could be easily applied in the classroom
- expert speakers, who provided valuable information about current developments in space science.

Teacher comments about the ESERO-UK Space Education Day

Overall it was a very interesting and rewarding day, with lots of stimulating talks and inspiring ideas.

I really enjoyed the conference and found it stimulating and thoroughly enjoyable.

Likewise, teachers who had been introduced to the ISS Education Kit were also highly positive about their experiences, with one teacher reporting that the ISS Education Kit meets a gap in the market as similar resources are hard to find. Teachers reported that they welcomed, in particular:

- the opportunity to discuss uses of the ISS Education Kit with a person who was knowledgeable about it. This was considered to be essential in maximising the value of the resource, as it enabled teachers to seek advice on how best to make use of it
- the opportunity to investigate use of the ISS Education Kit via practical tasks, enabling teachers to consolidate their understanding of how the resource works in practice
- the cross-curricular focus of the resource, which extends beyond science to a range of other topics. Therefore, the resource lends itself well to curriculum-wide projects and activities, including numeracy and literacy
- the sophistication and detail of the resource, including lesson plans and links to online materials.

4.2.2 Confidence and skills to use space education resources

When asked about their views prior to their involvement in the case studies, most teachers appeared to feel, relative to other areas, less **confident and skilled** in using the topic of space in their teaching. This may be attributable to teachers' relative lack of previous professional development opportunities relating to space education. In all of the case studies where teachers were surveyed, positive impacts were observed in both of these respects, although, overall, they were more modest than in other areas.

In general, the greatest gains in confidence and skills levels were felt amongst primary school teachers. Possible explanations for this may include primary school teachers having taught fewer topics relating to space over the past year, and being less likely to have a specialist background in science than, for example, a secondary physics teacher. Teachers who attended the *Ticks the Box* training day for example, praised highly the wealth of practical activities they learned about and the 'hands on' nature of the day, which they felt enabled them to be much more confident and skilled in sharing their knowledge with pupils.

Teacher comments about the *Ticks the Box* training day

It's wonderful to have resources to take away and use with children. Having 'hands on' experience of the activities is also a great benefit.

The findings suggest that, given teachers' concerns about their confidence and skills, as well as the benefits in these areas realised by the case study activities, there may be a need to focus and develop activities to more closely meet the needs of teachers in terms of increasing their confidence and skills in using space in their teaching, and that **primary school teachers may particularly benefit from participating** in these types of activities.

4.2.3 Awareness of good practice

Across most of the case studies in which teachers were surveyed, the area in which the impact was less strong relative to others (although still very positive) was an increase in teachers' **awareness of good practice** in teaching STEM subjects. This suggests that schools would welcome replicable models to support them in implementing good practice within their own schools. However, where follow-up surveys were conducted with teachers in relation to *Space as a context for teaching science*, teachers reported a greater increase in their awareness of good practice as time progressed. This may suggest that when follow-up activities and support is built into teachers' development, they benefit from the opportunity to test out their own models and ways of working.

4.3 Impacts on teachers' classroom practice

In general, the case studies showed very high impacts in relation to developments in classroom practice. Teachers who attended the ESERO-UK Space Education Day, for example, reported that the conference had given them a rich variety of ideas to use in the classroom, as well as enabling them to make links with other teachers to share expertise and plan joint extra-curricular activities.

Teacher comments about the ESERO-UK Space Education Day

I thought it was a really good event. I took lots away from it and I will be using many of the things I have learnt to help improve the teaching of science in my school.

I found two contacts at the conference one of which has already been in contact to see if we can link some extra-curricular activities.

The case studies showed that impacts on teachers' *own* classroom practice were particularly strong. For example, teachers reported strongly that they would be able to apply their teaching to a range of real-world contexts, and increase the range of practical activities they offered to their students. This was closely followed by positive impacts on teachers' plans to cascade their learning further afield. This impact was reported most strongly where activities were more intensive or sustained. Teachers who attended *Space as a context for teaching science*, focused around the

development of the JWST, reported that they particularly valued the follow aspects of the course, which they would be able to apply in the classroom:

- opportunities to learn about the JWST and MIRI, and to gain an insight into current developments in space technology
- learning about advanced engineering techniques and their application in scientific research
- practical and affordable hands-on activities, particularly those delivered at ROE, which can be easily applied to underpinning theory and real world contexts
- opportunities to share ideas and good practice with teaching colleagues
- practical activities showing techniques for teaching.

Teacher comments about *Space as a context for teaching science*

The sessions covering advanced engineering techniques (e.g. the image slicing mirrors) were intriguing and helpful to pass on to students as an illustration that advanced engineering is needed for cutting-edge scientific research.

The practical workshops were particularly useful especially when underpinned with the theory to accompany them.

The practical workshops fired my imagination into how to embed experiments into 'real world' scenarios.

Teachers reported that the themed approach to CPD taken in *Space as a context for teaching science* was particularly valuable in supporting them to teach advanced courses, on top of the support it provided more generally. For example, one teacher reported that, whilst the course was valuable for all aspects of their teaching, an up-to-date knowledge of the JWST would be particularly useful when teaching astrophysics, as there is a detailed topic on telescopes. Another teacher highlighted the importance of this approach in encouraging questioning and enquiry-based learning in their teaching, rather than assuming that everything taught about space is already known.

However, some teachers appeared to lose confidence in their ability to share their learning with other schools as time progressed. For example, a high proportion of teachers attending *Space as a context for teaching science* planned to disseminate their learning to other schools after the first part of the course, but by the second part of the course the strength of this impact had diminished. Therefore, the transfer of learning between schools may be an area in which teachers would benefit from additional, specific support. Generally, impacts relating to teachers' awareness of space-related careers and their ability to explore these in the classroom also appeared to be lower than in other areas, suggesting that teachers would welcome further specific information about career routes and employment opportunities to enable them to guide their students more effectively. This echoes the findings of the

early teacher surveys administered by Space Ambassadors in autumn 2010, which identified teachers' awareness of careers in space as a particular priority.

4.3.1 Future use of space as a context for teaching STEM subjects

Across all case studies, there was a highly positive impact on the future likelihood of teachers and schools using space as a context for teaching and learning. Teachers who attended the *Ticks the Box* teacher training day, for example, spoke positively the range of practical, real-world activities they will be able to undertake with their pupils in the future.

Teacher comments about the *Ticks the Box* training day

I will be using the pack of activities as a backbone for a week's activities called 'Out of this World' which the whole of key stage 2 will be working on. It will link in with work in lots of other areas of the curriculum including literacy, numeracy and art! We might even kick the week off by finding evidence that Martians have visited the school during the half term holiday! We will also be observing Mars through the Bradford Telescope and following the progress of the latest mission to Mars!

Whilst at Glyncod Comprehensive School it was apparent that this future use would focus around curriculum activities, in particular the GCSE Astronomy curriculum, the findings from other case-study teachers suggested that the activities would have a useful application in the curriculum as well as within a range of enrichment activities. Introduction to the ISS Education Kit, for example, appeared to have resulted in positive impacts on teachers' future plans to use the resource in their teaching, as well as their plans to use space as a context for their teaching more generally. Whilst most teachers reported that they would be likely to use the kit as part of their national curriculum teaching, many reported that they would use it for a special event. Such special events included, for example, celebration events, cross-curricular space projects, science clubs, and space days/weeks. Similarly, teachers who attended the ESERO-UK Space Education Day reported that they would run special events including:

- GCSE evening classes and astronomy events (e.g. observations of the night sky)
- events linking with other local schools and colleges
- use of space as part of off-timetable STEM enrichment days
- science clubs, astronomy clubs, and clubs for gifted and talented pupils
- public lectures, parent events
- summer schools and weekend master classes
- outreach programmes for feeder primary schools.

Interestingly, where follow-up surveys were completed, a greater proportion of teachers reported that they would use what they had learned in the national curriculum as time progressed. This suggests that teachers are becoming more

conversant with the range of potential applications of their learning within the curriculum as their skills become more developed. Related to this, it also appears to be the case that where activities were focused around a specific resource, plans for future use do not appear to be restricted to just this resource. For example, teachers who were introduced to the ISS Education Kit reported that they planned to make greater general use of space in their teaching, as well as greater use of the kit itself.

4.4 Impacts on students

Whilst the remit of this study did not extend to detailed exploration of impacts on students themselves, in two of the case studies (*Space as a context for teaching science*) and Glyncoed Comprehensive School) it was possible to explore teachers' perceptions of how students had benefited.

In both case studies, school and university staff observed considerable impacts on students' **enjoyment of STEM subjects**. At Glyncoed Comprehensive School, this was particularly apparent amongst students who had previously shown a lack of interest in science: situating their learning within an engaging thematic context appeared to inspire them, and supported them in acquiring a grasp of complex mathematical and scientific concepts. In particular, staff Glyncoed Comprehensive School observed impacts in relation to students':

- enjoyment of astronomy topics, and of science more broadly. This was particularly apparent amongst students who had previously shown a lack of interest in science
- attainment in GCSE Astronomy. Of those who entered the GCSE examination in June 2011, four were awarded A grades, 16 were awarded B grades, seven C grades, four D grades, and 1 E grade.

Most Year 9's found GCSE Astronomy easier than some of the abstract aspects of science, possibly because you can apply it.

The school were very pleased, and for the short amount of time we had to do it all in, and considering they were a mix of Year 9 and Year 10, I think they did great!

Faulkes Telescope Project staff member

Research participants also observed a number of 'ripple effects' arising from the course. Firstly, it was observed that students' achievement within the GCSE Astronomy course had been transferred to their success in other subjects. Many of the students demonstrated a higher degree of knowledge in other science courses, particularly physics, and the mathematical calculations they have learned in GCSE Astronomy, for example advanced logarithms, have proved extremely valuable in enabling them to develop their skills in mathematics.

[Students] thoroughly enjoyed the course and girls are now very knowledgeable in some science courses, especially physics.

School teacher

Secondly, participating students' enjoyment of the GCSE Astronomy course has ignited an interest amongst younger students. A teacher from the school reported that the course is 'not only sparking interest amongst girls involved in the project but also those lower down the school, which is really exciting'.

When teachers who attended *Space as a context for teaching science* were asked to reflect on the impacts they had observed on their students as a result of the activities they had introduced following the course, they also observed impacts in relation to students':

- increased confidence in STEM subjects
- improved problem-solving and investigation skills
- increased interest in further STEM study
- development of transferable skills (e.g. literacy and social skills, ability to conduct extended pieces of work on a given topic, and presentation skills).

Teacher comments on *Space as a context for teaching science*

By teaching an engaging topic through a fully integrated Assessing Pupil Progress (APP) suite of lessons the general scientific skills of pupils has improved. Most improved was the ability of students to write and construct extended pieces of work on a topic because they were more interested in the subject content.

We used a JWST summary paper for literacy - read for understanding - which they engaged with far better than normal.

4.5 Overview

The case-study findings clearly demonstrated that all five case studies had resulted in meaningful impacts for those involved. These impacts often appear to have been realised as a result of the combined efforts of ESERO-UK and its partners. Whilst it was possible to explore more far-reaching impacts in some case studies more so than others, where comparisons could be made it appears that, broadly speaking, no individual case study resulted in more strongly reported impacts than another.

The implications of this are two-fold. Firstly, this suggests that **there is a place for all types of support offered within the case studies**, ranging from general support for a wider audience of teachers to a much more focused, tailored and targeted approach towards smaller groups. Secondly, it suggests that there are a range of routes by which these impacts can be brought about, indicating that ESERO-UK and associated delivery organisations should be **confident in the suitability of their flexible and responsive approach**.

5. Recommendations and concluding comments

This section explores ESERO-UK's key partners and stakeholders' recommendations for the future of the development of the organisation, in light of its successes to date, and makes some concluding comments.

5.1 Recommendations

ESERO-UK's key partners were asked to comment on key areas they would like to see developed in the future. Whilst, overall, they felt that ESERO-UK had made good progress to date and were highly positive about the future of the organisation, they identified a number of areas that may benefit from further development. Many of these areas have already been recognised by the ESERO-UK team and are currently being addressed. Their recommendations included:

- development of a deeper **understanding of who is providing space education**, and to find ways of supporting these organisations, to improve quality and share best practice. To begin this process, ESERO-UK and its partners plan to hold a provider conference in 2012
- further **dissemination and promotion of ESERO-UK** including, for example, good practice case studies and teacher vignettes on the ESERO-UK website
- establishment of **clearer protocols** for determining which resources should be published on the ESERO-UK website, so that teachers and others are clear about where to find the information they need. This may include, for example, consideration of how best the UK Space Agency can support ESERO-UK with this process
- development of more **rigorous procedures for quality assurance** of teacher resources in the eLibrary. ESERO-UK has begun to address this through, for example, the recruitment of a teacher fellow, as well as a panel of teacher reviewers to evaluate these resources
- continued work with schools to **train them in the use of space education resources**, in particular seeking out cost-effective ways of achieving this aim (e.g. partnership working, school clusters).

Additionally, findings from the research suggest that teachers would welcome further support in the following areas:

- development of the confidence and skills to use space in their teaching, with a specific focus on how to **cascade learning to their colleagues** within and between schools
- further **information and guidance about the range of career routes** and employment opportunities relating to space, to enable them to guide their students more effectively

- provision of **replicable models of good practice**, including real-life examples, which could be applied in their own classrooms. Such materials could, for example, be made available on the ESERO-UK website.

ESERO-UK may also wish to consider new ways of supporting Space Ambassadors to engage with space industry partners at regional level, with a view to enhancing further the value and impact of existing educational networks. This might include, for example, dissemination to industrial colleagues about the benefits of involvement with ESERO-UK.

5.2 Concluding comments

The findings presented in this report highlight the many achievements of ESERO-UK in implementing a **range of effective strategies to promote and support space** as a context for STEM teaching and learning in schools. Feedback from schools demonstrates the wide range of approaches that can be used to support space education and the range of positive outcomes that can arise from them. It is therefore evident that ESERO-UK plays an important role in supporting, adding value and drawing together existing space education provision. Likewise, feedback from stakeholders and key partners shows that the work of ESERO-UK team is highly valued by their peers, and has been an important means of consolidating and strengthening partnerships across the space and STEM education agenda. ESERO-UK may wish to consider some of the recommendations provided above, with a view to strengthening further its ability to initiate, enable and promote effective space education in schools.

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