Impact case study (REF3b)

Institution: Liverpool John Moores University

Unit of Assessment: 9 (Physics)

Title of case study: The National Schools' Observatory

1. Summary of the impact (indicative maximum 100 words)

The National Schools' Observatory (NSO) is a web-based resource based at LJMU that gives UK and Irish schools free access to their own observations from the world's largest fully-robotic telescope – the Liverpool Telescope. Giving its participants unique and privileged access not only to the instrument itself, but also to the astronomical research carried out by the telescope, the NSO is a powerful blend of cutting-edge research, professional instrumentation and education that inspires, motivates and supports the learning of pupils of all ages and their teachers. Since its launch in 2004 the NSO has reached more than 4,000 registered UK and Irish teachers and their classes, with 60,000 sets of observations requested by schools. The NSO has been recognised by the House of Commons Science and Technology Select Committee as "so important to inspiring the next generation of scientists" **[Source 1]**.

2. Underpinning research (indicative maximum 500 words)

The sky varies with time, and investigation of that variation leads to further understanding of the physical processes that take place in stars and other astronomical objects. Some of the variations are fast and take place in hours to seconds or less, indicating that the objects are small. Yet their effects can be seen across space, indicating that the energy involved is large, and therefore that the physics is extreme. This motivated need for a time-domain branch of astrophysics has led to the development of robotic telescopes with a rapid response capability, with the Liverpool Telescope (LT) as a leading example. The early stages of the LT and its design can be traced back to the mid 1990s, when the scientific drivers behind and requirements of robotic telescopes were first clearly set out. From these initial seeds a detailed design was developed, including important advances in the scheduling systems and algorithms that are the key to the scientific power of robotic telescopes (see, for example, **[Ref 1]** (Steele: LT Director 2005-present, Carter: LT Project Scientist 1996-2005).

From the very start of the design process, it was realised that robotic telescopes facilitated new ways of remotely operating observatories, and opened them up to new communities, such as schools, whose pupils and teachers could not travel to distant mountains. Thus a strong driver for the LT project was to use the facility as an educational tool (at primary and secondary levels) by providing dedicated time and support (in the form of the NSO) as seen in **[Ref 2]** which brings together the expertise of Steele, Newsam (NSO Astronomer 1998-2006, NSO Director 2006-present) and Mottram (LT Software Engineer 1998-present). The result is a telescope and scheduling system that not only produces high-quality science data for a variety of science programmes but seamlessly supports non-professional use.

At its simplest level, the NSO uses the LT as an educational toy, with which even the youngest students can take their own images of planets, nebulae and galaxies and process them. The LT acts as a mind-expanding motivational facility for such students, thrilled by their participation in astronomy with a large, professional telescope in an exotic location.

At the next level, the NSO provides the raw material for exercises such as measuring the height of lunar mountains through the trigonometry of shadows.

At the most advanced level, since 2008, the NSO has provided an opportunity for students to participate in cutting-edge research, making observations that contribute to a research frontier, in areas as diverse as cataclysmic exploding stars such as supernovae and gamma-ray bursts (e.g. **[Ref 3]**), novae **[Ref 4]**, and transits of stars by exoplanets **[Ref 6]**. The educational use of the telescope grew, not just alongside the science programmes, but was directly influenced by (and influencing) them. Two exemplars will help to show the range of connections between research and impact.

The first concerns extra-galactic novae. Several LJMU researchers are involved in a variety of surveys to detect and study such novae including **[Ref 4]** and **[Ref 5]** which use two different techniques to collect as broad a set of data as possible. This expertise was brought together with the resources of the NSO to develop a combined research/education project that enables students

to hunt for novae in the galaxy M81.

The second example grows from collaboration between the LT and SuperWASP **[Ref 6]** to develop the high-time resolution, high-precision photometric instrument needed to follow-up potential exoplanet candidates, adding significant information to what is known about them. The instrument, RISE, has since been used in the study of a number of individual exoplanets (e.g. **[Ref 6]**) and has also led to an ongoing project where SuperWASP candidates are studied exclusively by schools and pupils using data from the LT in the search for new exoplanets.

3. References to the research (indicative maximum of six references)

[Ref 1] "Control software and scheduling of the Liverpool Robotic Telescope", Steele, I.A., Carter, D., 1997, Proc. SPIE Vol. 3112, p. 222-233, *8 citations, (Copy can be provided on request)*

[Ref 2] "Enabling schools and public access to the Liverpool Robotic Telescope", 2000, Steele, I.A., Newsam, A., Mottram, C., McNerney, P., Proc. SPIE Vol. 4011, p. 133-144, *1 citation, (Copy can be provided on request)*

[Ref 3]* "The Early-time optical properties of Gamma-Ray Burst Afterglows", Melandri, A.; Mundell, C., Kobayashi, S., Guidorzi, C., Gomboc, A.; Steele, I., Smith, R., Bersier, D., Mottram, C., Carter, D., Bode, M., O'Brien, P., Tanvir, N., Rol, E., Chapman, R., 2008, ApJ, 686, 1209, *10.1086/591243, 43 citations*

[Ref 4] "Classical novae from the POINT-AGAPE microlensing survey of M31 - I. The nova catalogue", Darnley, M., Bode, M., Kerins, M., Newsam., A., An., J., Baillon, P., Novati, S., Carr, B., and 11 co-authors, 2004, MNRAS, 353, 571-588, *10.1111/j.1365-2966.2004.08087.x, 35 citations*

[Ref 5]* "A Spectroscopic and Photometric Survey of Novae in M31", Shafter., A., Darnley, M., Hornoch, K., Filippenko, A., Bode, M., Ciardullo, R., Misselt, K., Hounsell, R., Chornock, R., Matheson, T., 2011, ApJ, 734, 22, *10.1088/0004-637X/734/1/12, 20 citations*

[Ref 6]* "Updated parameters for the transiting exoplanet WASP-3b using RISE, a new fast camera for the Liverpool Telescope", Gibson, N., Pollacco, D., Simpson, E., Joshi, Y., Todd, I., Benn. C., Christian, D., Hrudková, M., Keenan, F., Meaburn, J, Skillen, I., Steele, I., 2008, A&A, 492, 603-607, *10.1051/0004-6361:200811015, 48 citations*

(Citation data from the Astrophysical Data Service as of 23rd October 2013)

4. Details of the impact (indicative maximum 750 words)

The NSO is a web-based resource set up by LJMU to exploit the educational and engagement potential of the Liverpool Telescope (LT) **[Source 2**]. The target audiences are pupils in UK and Irish schools of ages 8 to 18 and their teachers, and since its launch in 2004 has reached more than 4,000 registered UK and Irish teachers, with 60,000 sets of observations requested by schools (growing from 2,700 requests in 2004/5, to around 1,500 per month in 2013) and around 1.5 - 2 million webpages served each year (the majority within the UK, but with a growing usage internationally) **[Source 3]**. This growth has resulted in the doubling in the amount of time that LT provides to the NSO from 5% to 10%, to support the increased reach of the NSO. In 2013, there has been a significant expansion of both research and NSO staff funded by LJMU, and this will lead to further projects.

The NSO has three overlapping components: a system to allow pupils and teachers to make their own observations alongside researchers on the LT; a range of projects that they can take part in, many of which have a strong research element; and a wide selection of support materials for those teaching astronomy or wanting to use astronomy and space science to support the teaching of other subjects, especially STEM. In addition, the ARI offers face-to-face support, work-placements and a wide range of talks, workshops and other events (in the 2012/13 academic year, NSO staff delivered over 200 hours of school activities and teacher CPD to a total of more than 10,000 pupils and teachers). This combination gives the maximum scope not just to motivate teachers and improve curriculum teaching, but to inspire pupils of all abilities, who can work inside or outside the curriculum at their own pace and in areas that particularly attract and interest them.

Oversight of the NSO is provided by the NSO Board, whose broad range of educational, astronomical, commercial and management experience from external organisations is supported by the ARI.

A recent (2013) independent evaluation on the NSO by the Centre for Science Education at Sheffield Hallam University examined the effect of the NSO on attitudes to STEM education and careers, identified the strengths and weaknesses of the NSO (to inform future developments) and created a framework against which longer-term impact can be assessed in the future. Using a mixture of online questionnaires and visits to schools, the evaluation showed that both pupils and teachers are "highly positive" of all aspects of the NSO and, in particular, that as well as enhancing astronomy and science education, use of the NSO has given pupils "more insight into the work of scientists" (68% of teachers agree or strongly agree, with < 6% disagreeing) and made them "more interested in science" (>80% agree or strongly agree, with only 4% disagreeing). In summary, the Sheffield Hallam academics concluded that the NSO "has unprecedented reach, and is one of the most significant educational initiatives in the STEM field linked to an HEI" **[Source 4]**.

These results are supported by internal evaluations and feedback from users: "It is much more involving than just using images that come from the internet" (Bethanie, age 16), "[It] gave me a real insight into physics and made me decide on what I wanted to do at degree level. Now I will be studying a Physics and Astronomy degree" (Simon, age 17), "[The NSO] gives us a powerful platform from which to proceed with inspiring students in science through astronomy." (Sarah, teacher).

As is clearly highlighted by this evaluation and feedback, the links with research are invaluable for achieving the impact. We have, therefore, an ongoing programme of developing research-led projects that are open to anyone and pupil-focussed, but which derive from and support LJMU research. These include the extra-galactic novae **[Refs 4,5]** and exoplanet search **[Ref 6]** projects mentioned in Section 2. Other projects include following and measuring the light curves of supernovae and measuring the positions and orbits of asteroids that as Near-Earth Objects might in future collide with Earth.

Recognition that the NSO's activities have had an important impact comes from a variety of sources beyond academic studies. Following advice from NSO Director Newsam, the Controlled Assessment (i.e. assessed coursework) of the *GCSE in Astronomy* was redesigned to enable students to use robotic telescopes, with the NSO cited as an exemplar in support material produced by the exam board Edexcel (now Pearsons). Working with partners across Europe (e.g. CERN, The European Physical Society and the Austrian Ministry of Education) the NSO has been actively engaged in several European projects looking at innovative use of technology in research-driven education (e.g. the *SkyWatch*, *Discover the Cosmos* and *Open Discovery Space* projects). The NSO also forms a key part of a recommendation by the House of Commons Science and Technology Select Committee to develop collaboration between BIS and DfE, recognising the importance of linking scientific research and education at the highest level. Finally, LJMU was awarded a Queen's Anniversary Prize in 2005 in recognition of the educational impact of the Liverpool Telescope **[Source 5]**.

In summary, the NSO is a research-led project that, to quote the Royal Anniversary Trust in their announcement of the 2005 Queen's Anniversary Prize, "is opening [astronomy] up to schools and enthusing large numbers of young people about the study of science and technology".

5. Sources to corroborate the impact (indicative maximum of 10 references)

[Source 1] Science and Technology Select Committee Report: www.publications.parliament.uk/pa/cm201012/cmselect/cmsctech/1425/1425.pdf

[Source 2] NSO Website: www.schoolsobservatory.org.uk

[Source 3] Annual NSO usage statistics: www.schoolsobservatory.org.uk/statistics

[Source 4] The independent evaluation of the NSO by the Centre for Science Education: www.schoolsobservatory.org.uk/evaluation2013

[Source 5] The Royal Anniversary Trust: http://www.royalanniversarytrust.org.uk/