In July 2013 we launched the OpenScience Laboratory (OSL) – an innovative online platform for practical science (Figure 1.). The OSL enables remote observations and manipulation or control of experiments via the internet, assessing real data through authentic interfaces. Furthermore, it incorporates instructional scripts, ICT tools for analysis of the results and learning analytics.

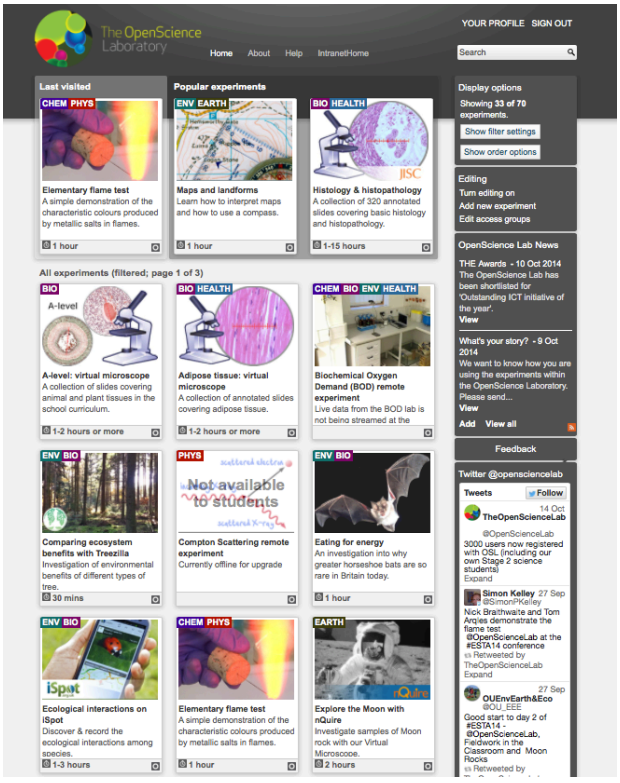

Figure 1. A page from the OSL store of practical science applications

Background and context

The OSL vision began in response to the challenges of distance learning in delivering practical elements of STEM subjects. It was soon recognised to be highly relevant to the development of *any* STEM students who need skills that enable them to carry out practical science via screens on their desktop computers and tablet devices. The scale and nature of many of the world's high profile 'experiments' (e.g. Large Hadron Collider, Hubble Space Telescope) require skills in using online instrumentation and data manipulation as much as they need lab-bench experience. Many experiments are operated through graphical-user-interfaces. Data are collected and analysed 'on screen'. Today's investigators are often obliged to operate at a distance (eg Earth-observation satellites, in-flight engine monitors, sports activity-logs, tele-clinics… and now, Open University lab classes).

Innovation

The concept of real online practical science is distinct from animation based on algorithmic simulation of experimental procedures. Though these have a limited role as interactive learning tools they are not realistic vehicles for hypothesis-based practical enquiry and training. By contrast, the OSL's innovative ethos is firmly rooted in access to real data through authentic interfaces, enabling student-led inquiry: learning proceeds from frustrations and mistakes as well as from discovery. This stance was critical in gaining credibility among academic colleagues.

We have so far developed about 50 online practical investigations. Figure 2. opens up one of them revealing the underlying structure of the OSL. Figure 3. shows some of the variety of applications.

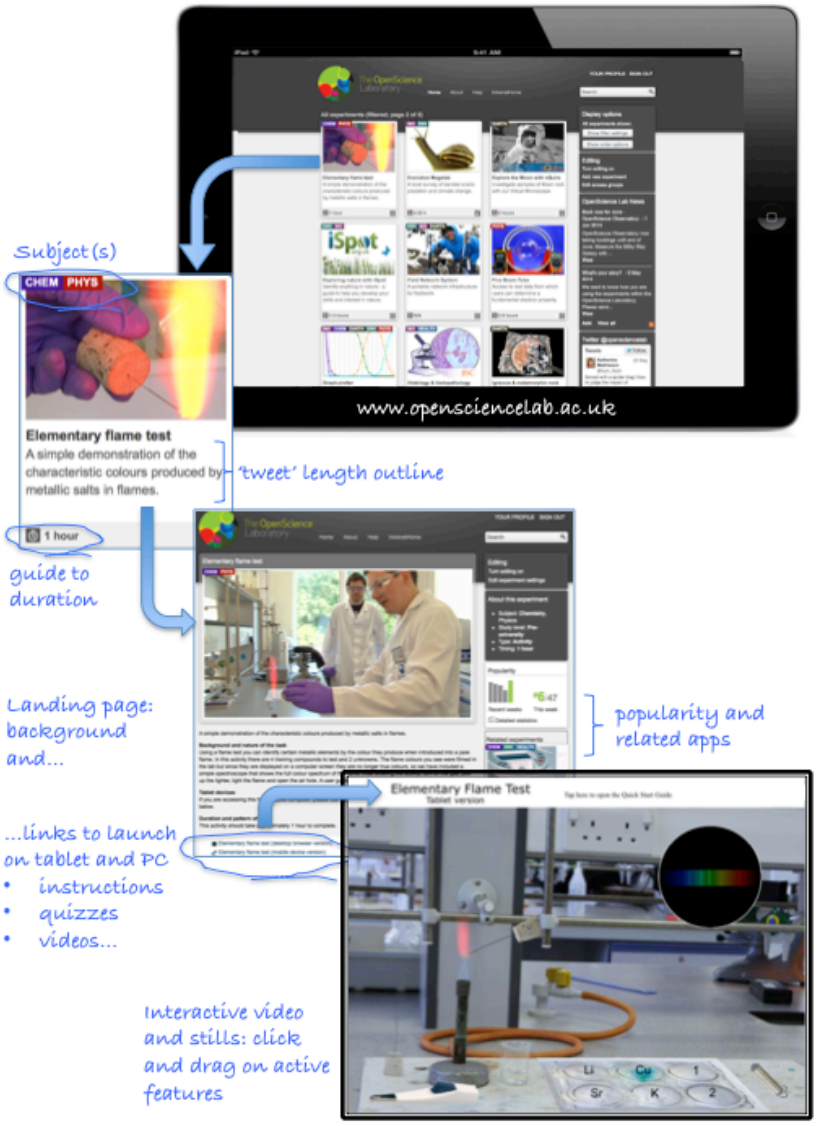

Figure 2. The OSL unwrapped for an interactive screen experiment

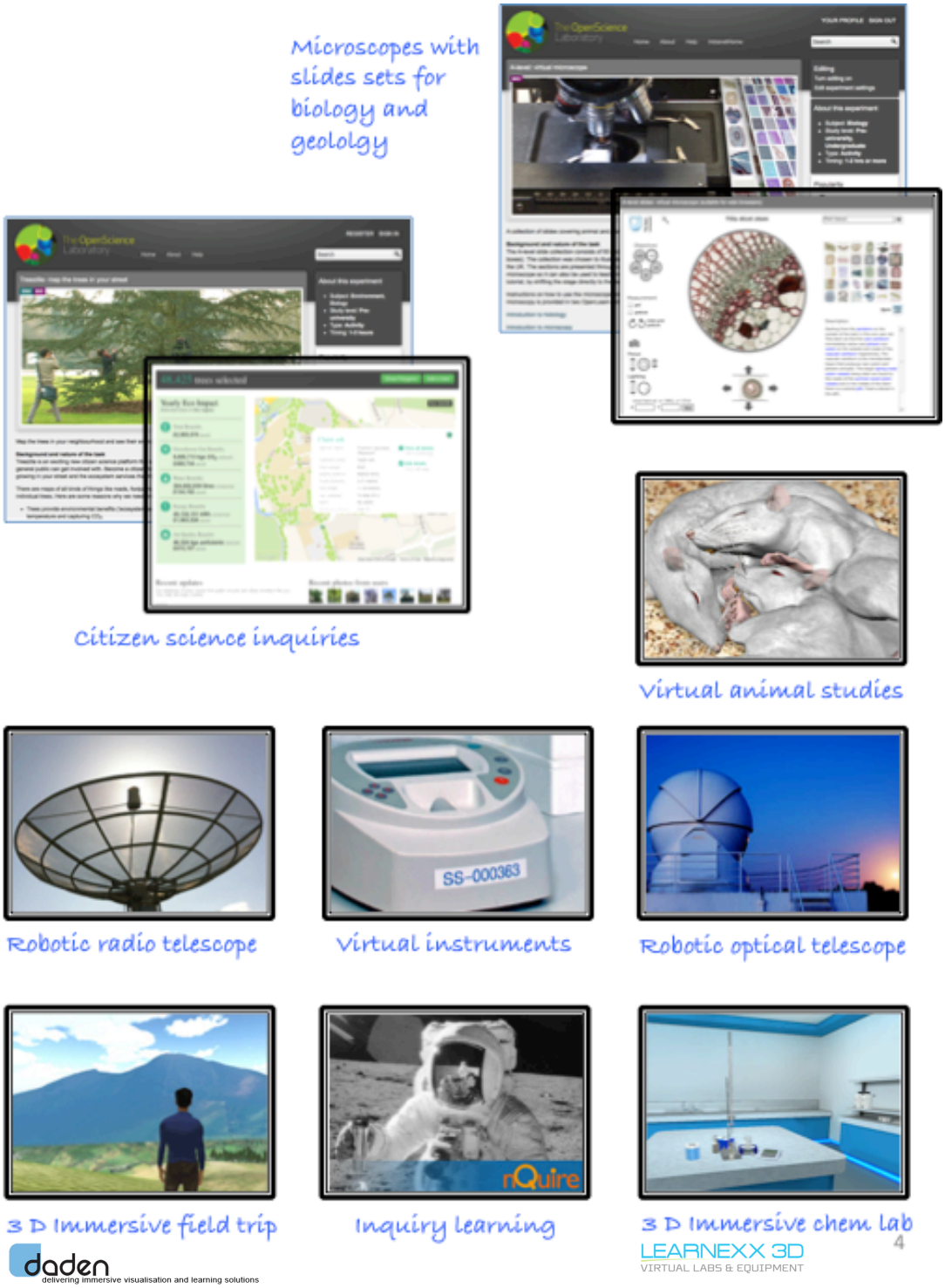

Figure 3. Some of the variety of approaches to practical engagements in the OSL

The OSL pioneer team

In partnership with The Wolfson Foundation, we engaged our excellent teachers, leading researchers and software developers in the creation and evaluation of authentic and effective online practical enquiries; commercial software enterprises were also engaged. Our intention has been to transform the experience of learning practical science. To build our understanding of online practical science education we have initiated a PhD and academic visitor programme aimed at assessing aspects of the OSL.

The team

Core team
Co-Directors: Prof Nick Braithwaite & Prof. Steve Swithenby
Project Managers: Dr Kat Garrow & Dr James Smith
Production Coordinators: Brian Richardson & Joe Mills
Project support: Tracy Bartlett & Beverly Casling

Academic Investigators/Project Leaders
Dept. Earth, Environment & Ecosystems: Dr Tom Argles, Dr Angela Coe, Dr Sarah Davies, Prof Nigel Harris, Prof Simon Kelley, Prof Jonathan Silvertown
Dept. Physical Sciences: Dr Silvia Bergamini, Dr Jim Hague, Prof Bob Lambourne, Dr Chris Barrett, Dr Paul Hatherly, Dr Ulrich Kolb, Prof Glenn White
Dept. Life, Health & Chemical Sciences: Prof David Male, Dr Eleanor Crabb, Dr Vicky Taylor, Dr Mark Hirst
Dept. Computing: Dr Shailey Minocha, Prof Marian Petre
Knowledge Media Institute: Prof Stefan Rueger
Institute of Educational Technology: Dr Liz Fitzgerald, Prof Eileen Scanlon, Prof Mike Sharples, Dr Will Woods

Research Fellow/Project Officer
Janice Ansine, Dr Eloy Villasclaras-Fernandez, Dr Mike Dodd, Rachel Ward

Research Students
Maria Aristeidou, Marcus Brodeur, Duygu Simsek

Software developers
Dr Greg Black, Dr Andy Sutton, Dr Will Rawes, Rob Barnes

daden
delivering immersive visualisation and learning solutions

LEARNEXX 3D
VIRTUAL LABS & EQUIPMENT

Graphic Design
Sarah Crompton, Matthew Rigby-Burr, Sara Hack, Diane Mole

IT
Sam Marshall, Bryan Waddington, Ian Cameron

Spreading the word

The OpenScience Laboratory launched at the Royal Society in July 2013. 180 champions of science education including representatives of learned societies, the Field Studies Council, Earthwatch, the British Science Association and science journalist attended. The lab was formally opened by Sir Eric Ash FRS, on behalf of our funding was partner The Wolfson Foundation.

The OSL is a virtual laboratory space where OU students do practical work. The same virtual laboratory is integrated into other, less formal learning opportunities. Awareness of the OSL is growing through social media, exhibitions and conferences (Figure 4.). We are now negotiating with other HE providers who want to share in the use and development of online practical science as pre-labs, in main labs and for outreach.

Figure 4. The OSL out and about on Twitter

Making an impact ()ctober 2014)

- 100,000 informal users,i ncluding those taking part in citizen science initiatives that are accessible via the OSL (Figure 5.).
- 3,000+ users registered with the OSL, to access to a wider range of experiments and experiences – these 'lab visitors' are getting a real taste of practical inquiry.
- 19 articles in the press, featuring in Science Omega, Nature, New Scientist, Education Guardian and the Sunday Times.
- 4 Exhibitions inc. the Higher Education Expo (2014) and BETT (2014).
- Talks and workshops at 18 national and overseas conferences – including ED-MEDIA (2013), EC-TEL (2013), a pan-African workshop in Nigeria (2013) and HEA STEM 2013/14),
- International visits (2014) to Brazil, Ghana and Russia.

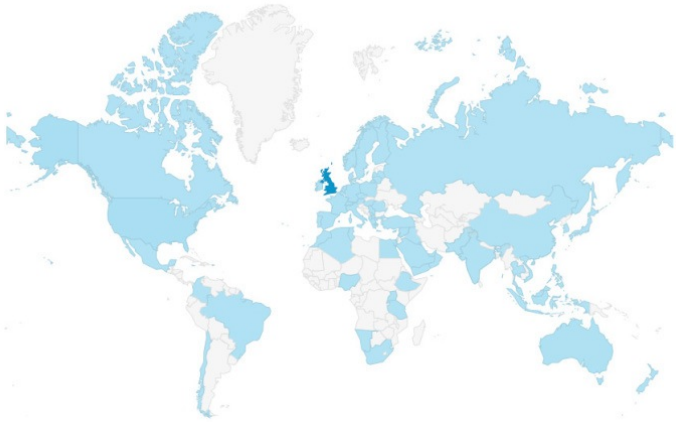

Figure 5. OSL global coverage – shade of blue indicates number of visits at Jan 2014: the sun never sets on the OpenScience Laboratory.

OSL on Youtube

- on the OSL itself http://m.youtube.com/watch?v=jf5FfXAz2fQ)
- on the launch of the OSL's Treezilla application at the MK Parks Trust http://m.youtube.com/watch?v=GfNlt2Ilvqs) in June 2013

Citizen science on the OSL

Treezilla aims to build a tree database that covers the UK and calculate the environmental impact and ecosystems benefits that these trees are providing. Citizen Science apps include "map the trees in your street" and "Comparing ecosystem benefits". Treezilla has prompted considerable interest from local authorities who now consider the economic and environmental benefits of their tree stock. Treezilla was developed as part of the OSL project.

Apps based on the OU's popular iSpot website ("Ecological interactions" and "Exploring nature") are designed to engage the general public, so they will add their own observations, join in discussions and get help identifying what they have seen in the natutal world. iSpot currently has over 300,000 distinct observations.

Teaching, research and pedagogy

The OpenScience Laboratory (OSL) is being integrated into The Open Univresity's science curriculum and, by the end of 2014, several thousand students from seven OU modules will be passing through the doors of the OSL. Online practical science via the OSL has become a core element of our degree qualifications. Students will come to the OSL for their practical science throughout their OU studies. This deep integration into the OU curriculum will help ensure the long-term sustainability of the initiative.
The OSL's innovative approach to practical science is opening up new opportunities for taking labs and field-sites to students at any time of day, wherever they are. For the OU this is essential and it offers increased efficiency for conventional teaching as an environment for preparation and testing. We are keen to learn from this ground-breaking initiative and to share our learning with others. The OSL gives us a unique opportunity to explore, analyse and evaluate new ways to learn about science. We have therefore established a team of postgraduate students working towards PhDs about the learning of practical skills (Fig 1.) and a visiting researcher programme.

"*One of my goals as a postgraduate researcher will be to identify, enhance and innovate techniques for the promotion of scientific understanding both amongst actual students and informal "citizen scientists", particularly as regards virtualisation and remote access to elements of practical and laboratory science."*
Marcus Brodeur
Engagement and Learning Through Remote Access to Practical Science

"My PhD broadly aims to scaffold "citizen science" with Learning Analytics. Unlike common thoughts on citizen scientists who are mostly seen as data gatherers only, this project aims to find out how we can develop citizen scientists' everyday language and ways of thinking and writing, into scientific discourse."
Duygu Simsek
Helping Citizen Scientists Read and Write Like Scientists: Learning Analytics and Authentic Inquiry

"My PhD research is on Citizen Inquiry. Citizen Inquiry is an innovative way to involve non-experts in scientific investigations through informal online networks of self-managed inquiry. My main focus is to explore the creation of self-sustained communities of scientific inquiries, and the measures for scientific discourse and practices. To explore the potential of Citizen Inquiry, a series of design-based studies are developed to help in understanding and improving the engagement of citizens in online scientific investigation."
Maria Aristeidou
Open Inquiry Learning in Citizen Science

"I have come to work with the OSL team on aspects of evaluation and new applications for the fantastic laboratory of practical activities that they have."
Prof Nazirah Azli
OSL Visiting Professor, Deputy Dean (Production and Support System) at the School of Distance Education (SDE), Universiti Sains Malaysia