

Public Outreach at RAL: Engaging the Next Generation of Scientists and Engineers

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Abstract. The Rutherford Appleton Laboratory (RAL) is part of the UK's Science and Technology Facilities Council (STFC). As part of the Royal Charter that established the STFC, the organisation is required to generate public awareness and encourage public engagement and dialogue in relation to the science undertaken. The staff at RAL firmly support this activity as it is important to encourage the next generation of students to consider studying Science, Technology, Engineering, and Mathematics (STEM) subjects, providing the UK with a highly skilled work-force in the future. To this end, the STFC undertakes a variety of outreach activities.

This paper will describe the outreach activities undertaken by RAL, particularly focussing on those of the Scientific Computing Department (SCD). These activities include: an Arduino based activity day for 12-14 year-olds to celebrate Ada Lovelace day; running a centre as part of the Young Rewired State – encouraging 11-18 year-olds to create web applications with open data; sponsoring a team in the Engineering Education Scheme – supporting a small team of 16-17 year-olds to solve a real world engineering problem; as well as the more traditional tours of facilities. These activities could serve as an example for other sites involved in scientific computing around the globe.

1. Introduction to Public Engagement at STFC & RAL

The Science and Technology Facilities Council is one of seven research councils in the UK. It is responsible for supporting, co-ordinating and promoting research, innovation and skills development in seven distinct fields [1]. This includes running several large facilities, some of which are located at the Rutherford Appleton Laboratory at Harwell campus, about fifteen miles south of Oxford. These facilities include the ISIS neutron spallation source [2], the Central Laser Facility [3], the UK Worldwide LHC Computing Grid (WLCG) Tier 1 [4], the JASMIN Super Data Cluster [5] and various space engineering facilities [6].

As part of the STFC's Royal Charter, the organisation has a duty to generate public awareness, communicate research outcomes, encourage public engagement and dialogue, and disseminate

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knowledge in relation to the science and engineering undertaken [7]. To fulfil these duties, public engagement has been made one of the STFC's six strategic themes [8] for 2010 to 2020. The STFC also has a dedicated public engagement team with managers at each of the three main sites and computing is one of their five key outreach themes.

Three years ago, the Scientific Computing Department (SCD) started to fund a public engagement committee so that it could play a fuller role in the computing outreach of STFC and increase the amount undertaken, without impacting other outreach themes. SCD has provided £10,000 to this committee for 2015/2016, which will be spent on a variety of outreach activities ranging from one hour to one week long programming sessions as well as data centre tours and work placements.

2. Outreach Activities

Through its public engagement activities in 2014 STFC, as a whole, reached 334,000 school children directly and 18,000 teachers, who will go on to influence more school children [9]. Some of the computing outreach activities undertaken as part of that are described below.

2.1. The Ada Lovelace Challenges

To tie in with the international Ada Lovelace Day [10], RAL hosted six groups of thirteen to fourteen year-olds for a day long introduction to the world of microcontroller hardware and software. The day also included a tour of the SCD machine data.

The teams consisted of four students, each of whom took one of two roles. One role was responsible for programming and the other role was responsible for the hardware. Team members alternated roles throughout the day to allow team members experience of both. The two team members in the programming roles used a software development technique called "pair programming", in which two programmers work together at one workstation. One, the driver, wrote code while the other, the observer, pointer, or navigator, reviewed each line of code as it was typed in. The two programmer roles were switched frequently.

Teams were given one of three challenges:

- Create a temperature sensing circuit and report the temperature via five different coloured LEDs.
- Create a system for tapping out Morse code using buttons and LEDs
- Measure the distance from the spacecraft (the Ada Lovelace) to the ground and calculate her rate of descent.

Each team was given an Arduino starter kit [11] and a laptop with Ardublock [12] installed. Ardublock is a graphical programming environment, similar to scratch [13], which makes programming physical computing with Arduinos as easy as drag and drop. Following a brief introduction to breadboards, wiring up simple circuits and Ardublock, the teams were left to design and build both software and hardware to complete their challenge with staff providing debugging assistance only.

The day was a success, with each team completing the challenges and being able to present their circuit to the other groups before the day was over. The challenges were also linked into STFC science, such as the temperature sensor system being similar to the one used to monitor the environmental conditions in the data centre and other laboratories on site.

In the 2015/2016 academic year, three Ada Lovelace Challenge Days are planned, with the first coinciding with Ada Lovelace Day 2015 and another to be hosted at STFC's Daresbury Laboratory.

2.1.1. 1 hour variant

The Ada Lovelace Challenges have also been adapted to work as one hour long sessions in two different ways.

The first is purely a hardware challenge. The Arduinos are provided pre-programmed with the temperature sensing code uploaded to them and the groups are required construct the hardware from a circuit or breadboard diagram. This has the advantage of not requiring laptops for the session as no programming is needed; the Arduinos are supplied power by a powered USB hub. This format has worked well with children as young as eight.

The other variation is a step by step guide to constructing the temperature sensing circuit: building up from wiring up LEDs; programming LEDs to flash; programming LEDs to flash when a button is pushed; culminating in programming LEDs to flash when the temperature is above a certain threshold. This variation allows for slightly larger groups as there are both hardware and software tasks involved.

Thematically, the challenges have also varied to suit the wider context of the day they were part of. For example, the most recent session was styled as building temperature sensors for an Earth observation satellite, which STFC is involved with the construction of, as part of a National Space Academy [14] day hosted at RAL.

2.2. Engineering Education Scheme

Departments at RAL have taken part in the Engineering Education Scheme [15] (EES) for many years. Between four and six seventeen to eighteen year-olds are paired up with engineers from local companies and set a real world engineering problem to solve. SCD has mentored teams for a number of years. In 2014/2015 three members of the department mentored a team from a local school to develop an interactive display for the RAL visitor centre. They used a Raspberry Pi to display a live data feed from the RAL WLCG Tier 1 Infrastructure on an A0 sized map with LEDs that flash in different colours to represent the amount of data being transferred between the Tier 1 and other selected WLCG sites.

2.3. Young Rewired State

Young Rewired State [16] (YRS) is a worldwide community of “digital makers” aged 18 and under. YRS have the aim of introducing these makers to like-minded peers, and expert mentors, at free events (Hyperlocals) around the world, where makers use freely available open data to build apps, websites and algorithms to solve real world challenges [17]. RAL hosts one of these Hyperlocals every month with staff members giving up time on Saturdays to act as mentors.

RAL also acts as a centre for the Festival of Code, the largest hack event in the world [18], which sees over 1200 young people gather all across the UK to prototype digital solutions and culminates in a single Festival weekend.

2.4. Work Placements

STFC and SCD take on work experience placements every year. In 2015, RAL received just short of five hundred work experience applications and SCD was able to provide places for nine of these. The biggest hurdle to an application being successful is finding supervisors willing to take on a work experience student, with several of those willing currently taking more than one.

SCD also takes on several summer students, Erasmus students and Year in Industry (YINI) students each year. Summer students are undergraduates who take a work placement between consecutive years at university. Erasmus students are part of a European exchange programme which provides placements of between three and twelve months, as part of a degree-level course. YINI

students are yearlong placements for pre-university and undergraduate students, either as part of a degree or as a gap year.

All student placements are placed with a group for the duration of their placement and become full members of the team. They are given real work with real benefits, many of which continue to be used after the student has left.

2.5. Programming Masterclass

As part of the work experience process, SCD staff members give up as much as a week of time to teach the intake basic programming skills, with Python being the language of choice. The aim of this class is to ensure the work experience student can spend as much of their limited time on site doing useful work, as opposed to learning the basic programming that underpins most of modern science.

2.6. Data Centre Tours

Often when a school child, teacher or member of the public comes on site for an event, they will be given a tour as part of the event. The data centre at RAL is a frequent destination for those at RAL for computing events, with members of staff volunteering to guide people around the data centre and explain the work that SCD undertakes. This gives schools and the public a rare opportunity to see supercomputers and multi Petabyte data processing systems.

2.7. Teacher Continued Professional Development

The RAL site hosts Computing at School [19] (CAS) meetings. CAS aims to promote the teaching of computer science at schools and counter any impression of computing being dull or pedestrian. Their goal is to put the excitement back into computing at school [20].

With a portfolio of software applications in fields including quantum chemistry, molecular simulation, solid-state physics, materials simulation, engineering and environmental simulations, SCD is in a position to help develop interest in computing. Not only is the work undertaken by the department varied, the staff members are enthusiastic and this enthusiasm can help teachers and children see computing as the exciting field it is.

2.8. I'm a Scientist, Get me out of here!

I'm a Scientist [21] is a free online event where school students meet and interact with scientists, part funded by an STFC Public Engagement award. It is an X Factor-style competition between scientists, where the students are the judges. Students challenge the scientists over fast-paced, online, text-based live chats. They can ask the scientists anything they want and vote for their favourite scientist to win a prize of £500 to communicate their work with the public. Staff members of the SCD have taken part in this scheme, answering questions put to them by eleven to sixteen year-olds online on the subject of 'big data'.

2.9. Harwell Campus public open week

STFC regularly opens up the RAL site to schools groups and the members of the public during the course of the year. In July 2015, the entire of Harwell Campus will open up for a series of open days.

One of these days will be a schools day, where 1,600 school children are expected to attend. During this day, the children will take part go on tours of the data centre, attempt the Ada Lovelace challenges and visit one of the campus' visualization suites.

Another of these days will be a public open day, where of order 10,000 people are expected to attend. Every hour there will be four tours of the SCD data centre, as well as displays of recent posters, highlighting the work that SCD does.

3. Reasons to be involved with Outreach

Many SCD staff are able to recall being inspired by Computing and STEM public engagement programmes of other institutions as a child and teenager and as such understand the importance of these activities. Outreach provides the opportunity to “give back” and the onsite facilities and the work that the STFC does means staff are uniquely positioned to enthuse the next generation of scientists and engineers, encouraging young people to consider careers they may not have done otherwise. It is also an opportunity for staff to show off the cutting edge science and technology they encounter every day and practice skills outside of those required by their core responsibilities, such as presenting to different audiences. The department itself benefits from outreach work as well. An example of this is the WLCG Tier 1, which is currently using approximately ten different applications developed by Erasmus students and recently hired one new system administrator and one Year in Industry post as a direct result of participating in Young Rewired State.

Most importantly of all, outreach is enjoyable. And because of this, staff members involved in SCD’s outreach are frequently willing to give up their own time to take part in weekend and evening events.

4. Summary

Outreach encompasses activities that engage students and the general public; help inform them about STEM work and interest them in science. Often, these activities take the form of tours, workshops, student placements, public lectures [22] and road shows [23]. The benefits of such activities are numerous and not limited to those on the receiving end:

- The student or member of the public being engaged gets to leave with an understanding of a new area of science, potentially inspiring them into a career in STEM
- The person giving the tour or running the activity benefits as well, be that improving presentation skills or answering an interesting question that sends their research down a completely new route.
- A more scientifically literate population may also lead to more funding for STEM being available in the future, as people begin to understand the economic benefits of STEM research.
- The organisation supporting the outreach may feel the benefits in terms of recruiting new staff. Both the number and the quality of new applicants may improve and the cost of advertising new positions may decrease as more high quality applicants become aware of the organisation.

SCD and its staff recognize the concrete benefits outreach can bring. Because of the strategic commitment from STFC, staff members are able to benefit from the varied and enjoyable development opportunities provided outside their core responsibilities by outreach, and at the same time meet STFC goals.

Opportunities to share experiences and best practices with other organisations would be most welcome.

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