Real Data, Real Science in a School or College!

Towards a National Class S.T.E.M. Programme

Abstract

I propose the development of an impressive STEM programme aiming towards ongoing active links with university or industrial research. There will be elements of physics, geology, space-science, computer programming and electronics. Benefits to students include the educational merits of getting their hands dirty, confidence in tackling extended project work, background research in these topics and a massive fillip to university/apprenticeship applications. Student's work may be able to count towards an E.P.Q. award or similar.

Institutionally one should see impressive press opportunities, university involvement and increased recruitment of the more able & keen technically minded students. Taking such projects out to feeder schools would be a very effective marketing tool. As an example of what can be achieved one only need look at the stellar work of Becky Parker et al. at Simon Langton Grammar School [1, 2].

Overview

Outside of my primary job teaching A-Level physics I am involved in developing novel pre-university level science projects. I propose creating a hands-on science programme acting as a beacon for the more enthusiastic science students. Allowing them to develop real science projects with links to university research departments.

I suggest starting with a system to provide real-time 24/7 monitoring of the earth's magnetic field. Effectively this monitors solar activity giving advance notice of solar storms and aurora. A mature project this has been well tested and promoted by myself via the Net [3], the 2016 & 2017 Newcastle MakerFaire and at a recent IOP physics teacher training event in Durham.

The system is monitored by a Raspberry Pi and an Arduino which record data and upload every few minutes to a website. One could come up with a suitable name such as *North-East Geophysics Network* with a website that partner schools could link into. This would display real-time graphs from the sensors.

Phase I

Students would build and test the magnetometer circuit integrating it with data monitoring hardware (Arduino, Teensy or similar) and connecting to the local network via a Raspberry Pi to log data and produce research quality graphs. The sensor needs to be sited as far from cars and other metallic movement as possible in a thermally stable environment. A store room or facilities area would be suitable - failing that the system can be buried in the grounds in a waterproof housing. Students can then monitor the output from any networked device.

I estimate one session a week for a term to get the core system up and running. Students could then take this out to feeder schools building satellite stations n.b. This is neither an untried project nor process. The system has been debugged with well in excess of 100 hours of my time spent on programming alone. I have previously gone into two schools from my 6th form with similar electronics projects as well as running innovative STEM activities for many years. The difference here is starting with a mature project working toards an ongoing network of activities feeding data in real-time into a globally accessible website. Thus becoming one of the very few schools and colleges in the U.K. to undertake real-research. The educational merits are tremendous, publicity and recruitment opportunities awesome.

Phase II

Now one steps it up a level with two or more projects using interested students from phase 1. By this stage one would expect to have active university links with local physics,geophysics, astrophysics or geology departments. I suggest for the second phase constructing an infra-sound monitor using a 'mems' differential pressure sensor – follow ups would be an infrasound testing chamber and then experimenting with different infrasound microphones. In subsequent years these could be rolled out at neighbouring schools to form a monitoring network capable of capturing seismic activity and meteors in the upper atmosphere.

Long-term

Ultimately the aim will be to build a self-sustaining system where newer students begin by working on existing projects with older hands.

Educational Benefits

Few A-level science students have direct experience of real science. These types of project combine real science with real-world systems engineering. Students work in teams to build, test and install rather sophisticated realtime geophysics monitoring systems. These projects contains elements of physics, electronics, geology, space science, computer programming, and computer networking. When the initial install is up and running it can them be further developed, more or different magnetometer sensors, different locations, wireless links between the sensor and base station, statistical filters added to the software. I designed this to be sufficiently simple to allow construction by primary age kids (I have already done this) yet sufficient development potential for A and degree level students. It appeals to students combining physics, computing and electronics along with space science and geophysics.

Geophysics is under-appreciated, even at A-level despite the stellar job prospects. Such projects would promote physics, computing and geology.

School Benefits

- Feeder school pupils meet centre students, visit the site then hopefully are more likely to be recuited.
- Promoting interest in science and indepedant working.

- Publicity posters around the schools.
- Excellent press publicity.
- University Links
- There is public interest in Aurora [4, 5], the website would promote general interest in the centre.
- It would make the practice and perception of science more dynamic.
- Taking the lead rather than riding another's coat-tails.

Cost

The hardware costs are small. Each sensor rig will cost no more than £100 - probably nearer £80, less if the school has a spare Arduino or Pi. Staff time is the biggest cost but one may be able to get external funding from Ogden Trust or one of the Royal Societies. With the emphasis on geophysics mining companies may be a funding source.

Further Projects

If this goes well I have other related projects in development which would link in with this. I am looking into involving geophysics departments of N.E Universities.

Projects under active development include:-

- Monitoring movement of the ionosphere via military submarine transmitters.
- Geophysics magnetic surveying (a magnetic gradiometer) to survey archaeological sites. [1]
- Lighting detector - monitor stikes out to approx. 1000km.
- A national - possibly international infrasound detector network.
- Seismometers.
- Gravitational variation detectors.

Previous Experience

I have been active in various ad hoc projects with students for nearly 20 years. These have included:-

- Developing and teaching 'scientific computing' to A-level students.
- Teaching $\LaTeX\ 2_\varepsilon$typesetting to A-Level Physics and Maths students [6].
- Building a lighting detector.
- Building various earth-field magnetometers.

[1] Whilst the basic hardware design for this I am happy to share the more advanced software I am developing commercially

- Programming cryptographic analysis software.
- Running a HiSparc internationally networked cosmic ray detector [7].
- Installing and running an internationally networked seismometer[8].

I have lost track of the number of students who claim these projects have dominated university interviews.

References

[1] https://www.youtube.com/watch?v=MTv1N-BLTiM

[2] http://www.thelangtonstarcentre.org/

[3] http://www.starfishprime.co.uk/projects/EFM/EFM.html

[4] http://aurorawatch.lancs.ac.uk

[5] https://www.flickr.com/groups/aurorawatch

[6] https://www.latex-project.org/

[7] http://www.hisparc.nl/en/

[8] http://geoserver.iris.edu/content/ppuk