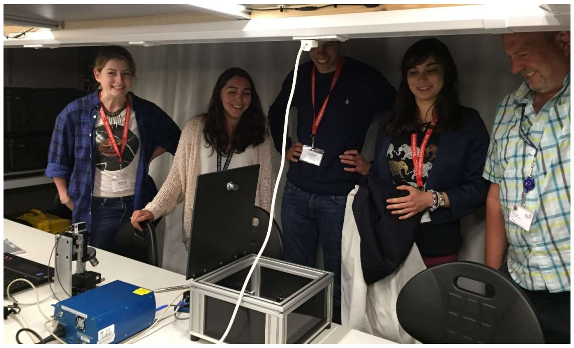

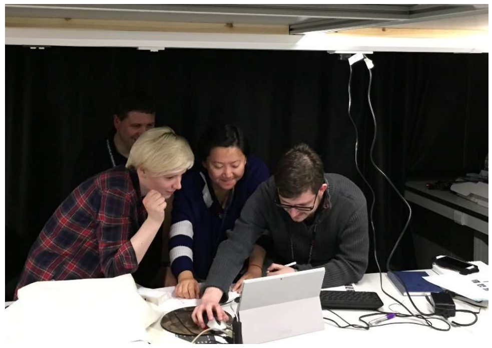

OPTIMA Case Study 2

Build your Own Spectrometer Course

TAKING APART THE BLACK BOX – REPONDING TO INDUSTRY NEEDS

Back to Basics

by Prof Karen Faulds (Strathclyde OPTIMA Director) and Prof Neil Shand (Dstl)

In the beginning...

As we considered how best to equip our CDT students with the skills to enhance their employability, one of the key aspects brought up by one of our industry partners, Dstl, was that the students need to get hands-on practical experience of building their own optical equipment using minimal components rather than using an off-the-shelf black box. Therefore we, in collaboration with Prof Neil Shand from Dstl, created the "Build Your Own Spectrometer" course to address this skill set identified by industry.

Course rationale and outline

"Build Your Own Spectrometer" is a hands-on course in which groups of students are given the necessary components to build a spectrometer. The course teaches, through a variety of lectures, workshops and independent study exercises, how to assemble a fully functional spectrometer. It gives a unique insight into how an optical spectrometer works as well as how to design, build and optimise optical spectroscopy systems. The students learn how different optical instruments based on a variety of imaging modalities *e.g.* Raman, Fluorescence, UV-Vis Spectroscopy can be designed from first principles. They ultimately build a spectrometer which they then 'pitch' to a potential customer. We have designed a bespoke 'SandBox' (see figure below) which consists of a box incorporating all the main components of a spectrometer. The SandBox is designed such that all the components can be changed; detectors, gratings, slits, fibres and mirrors, with multiple options being available for each component in the SandBox. The sides of the boxes are removable to easily allow all components to be manipulated by hand.

This course gives the CDT students a unique understanding of the techniques that they will be using throughout their PhD as well as in their future careers, whether they remain in optical imaging research after their PhDs or go into industry or work for instrument manufacturers. The current CDT students come from multiple backgrounds of differing disciplines and experiences including chemistry, biology, physics, and medicine therefore they have varying levels of knowledge of the underlying principles of optical spectroscopy. This course allows students to get away from thinking of the instrument as simply a 'black box' for analysing a sample and allows them to understand how instruments work, what the limitations of instruments are, as well as allowing them to think how they could design their own instrument depending on application and cost restrictions.

As well as helping them with their current understanding of their PhD, this course will also greatly add to their employability combined with the other courses they will take during the CDT programme. In short, this course teaches students, over the course of a week, what it would otherwise take years to learn through simply using commercially available systems, developing a full understanding and appreciation of how optical spectrometer systems work and can be improved within their own research.

Lectures

Informal lectures are given on the components of the spectrometer and the difference between different types of components in terms of applications and performance *i.e.* detectors, gratings, slits, optics, optical fibres, light sources etc. The basics of the requirements for different types of spectroscopy is also covered, in particular absorbance and reflectance spectroscopy, Raman and fluorescence. Advanced techniques such as SERS, SORS, metal enhanced fluorescence are also discussed including group discussion on some future concepts such as miniaturisation and low cost spectroscopic devices.

Guided Practical

In a taught practical the students are split into groups and are then introduced to the SandBox, see figure below. In these initial sessions the students are taught how to calibrate the detector and experiment with the different gratings, fibre optics and slits available to them to work out what effect these different components have on the system. They are asked to measure the resolution of the system and determine FWHM using different calibration lamps and laser sources and work out the effect on the resolution when these different components are changed.

STUDENT PERSPECTIVE

"I really enjoyed the microscope course, it was really helpful to see the inside of a spectrometer and understand the functions of all of the parts inside to understand how it works and how it's actually generating signal from your sample, rather than just seeing it as a 'black box' that spits out spectra. I thought Neil delivered it really well, there was a good balance of theory and practical work, and he was really hands-on in helping us when we got stuck"

Catherine Lynch, OPTIMA student

Assignment and group work

The students are given a customer briefing document where they have to develop a spectrometer for a particular application and within a specified budget. Once each group have received their brief they work in groups to design and develop a working spectrometer over the subsequent days.

Assessment

The assessment is based around the 'Pitch' that they will present to their customers.
They must present their solution in the form of a Power Point on their spectroscopic Sandbox design to the customers. This includes the design of their system and why it is better than competitor systems already on the market. The assignment involves some research into existing technologies and suggestions some novel techniques, some which they will hopefully have implemented in their design. The students should look to identify "disruptive" technologies and provide an aspect of "Horizon scanning" where they have identified technologies such as miniaturisation and integration of the systems e.g. MEMS type devices as potential solutions.
They must produce a one page specification sheet/marketing flyer for their spectrometer and present a practical demonstration of a working spectrometer which will produce a spectrum of the customers' material.

SAND BOX (below)

1. Grating
   Each system has 4 gratings in a wheel that can be rotated in and out of the path

2. Fibre
   Coupling of fibre from light source to sand box

3. Slits
   Each system has 4 different slits which can be easily changed manually

4. Mirrors
   Allow focusing of light onto detectors and grating

5. Detector
   Interchangeable with several detectors available for each Sand box.

INDUSTRY PERSPECTIVE

"I believe the new management at Ocean [Optics] are … fully engaged with the educational involvement. On a recent visit to Dstl they asked whether we might be interested in offering the course to train their staff!! They see this as valuable tool and something that could enhance their own training as such hands on opportunities are currently not available. They also seem keen to access the course materials etc"

Prof Neil Shand, Dstl

This course not only provides bespoke training in the fundamental workings of a spectrometer and allow students to build their own working system, it also develops their skills in entrepreneurship and marketing as they have to find the place for their spectrometer within the current and future technology market as well as satisfy the 'customer' requirements.