MSc Physics Students Take Ownership of Their Learning With LabVIEW

NI Products Used: LabVIEW, myDAQ

Industry: Higher Education, Teaching

The Challenge
Ensuring the core modules of Cardiff University’s MSc Physics programme effectively teach advanced practical and research skills to students with different backgrounds, and balancing teaching to a skill level appropriate for a master’s degree and the finite amount of time available within an academic year.

The Solution
Using the LabVIEW platform and its application to hardware interfacing to solve real-world problems through 10-week micro projects that run parallel to formal skills-based lectures, workshops, and laboratory sessions within the core Advanced Experimental Techniques in Physics module of the programme.

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About Our Postgraduate Taught Master’s Programmes
At Cardiff University, our MSc (Master of Science) Physics and Astrophysics programmes combine bespoke core modules that use aspects of research group organisation and operation to build a sense of community and enhance learning for students.

Figure 1. Cardiff University is one of the top universities in the United Kingdom and a member of the Russell Group. Our world-leading research was ranked fifth amongst UK universities for quality and second for impact.

Our master’s students have a dedicated area that incorporates their meeting and seminar room, two bespoke teaching laboratories, and an office for the two MSc coordinators, so they can deal with any issues that arise. In this purpose-built teaching environment, we conduct the core MSc modules across autumn and spring. Over the summer, students undertake research projects within our laboratories or in collaboration with our academic and industrial partners.

MSc Physics students sit the “PXT101: Advanced Experimental Techniques in Physics” module during the autumn term. A central task within this module is for students to conduct a 10-week micro project, which runs in parallel to formal skills-based lectures, workshops, and laboratory sessions based around learning programming using LabVIEW. By requiring that the micro projects include a LabVIEW coding element, the two parallel activities are effectively linked and mutually support each other.
Students organise their engagement with these projects outside of formal contact hours. The entire cohort meets weekly for a research group-style meeting containing action learning sets to help students support each other and to prioritise and set goals for each week’s activities. By the end of the module, students who came to the course with no prior programming experience whatsoever can generate soundly designed and well-written graphical user interface (GUI) applications that communicate with actual hardware to solve real physics-based problems. Our LabVIEW Student Ambassadors are on hand during the term to offer additional support.

Having acquired a solid foundation in LabVIEW programming and its application, students can sit the Certified LabVIEW Associate Developer (CLAD) examination during the spring term. The opportunity to obtain this industry-recognised certification is a major source of added value for our MSc students and affords a definite advantage in a highly competitive technical job market.

The micro projects for the 2015/16 academic year have been eclectic in content and open-ended in design. All projects are designed to meet a specific need, such as returning an outdated piece of hardware to service or generating material for scientific outreach, and are designed to be run over several academic years, building on the foundation laid by successive cohorts. For example, brief descriptions of four micro projects in 2015 include:

**Micro Project 1—LabVIEW for Testing: Scanning Electron Microscope (SEM) Repair and Restoration**
A pair of students constructed a working SEM from a combination of existing, non-functioning parts from a commercial SEM and custom-designed components. They used LabVIEW to write the test application for the instrument and the bespoke components that they designed and built, which included a preamplifier stage and a moveable helical “Beetle” sample holder. Students will carry this project forward to 2016/17 to design and program a GUI to run the SEM itself. With these in place, the SEM can be useful for research again and save the School the considerable costs of replacing this instrument.
Micro Project 2—LabVIEW in Outreach: A Laser Interferometer Gravitational Wave Observatory (LIGO) Analogue
Another group constructed a desktop Michelson interferometer for use as an outreach diorama demonstrating, by analogy, the functioning of the LIGO gravity-wave detectors. They replaced gravity waves with water waves for this demonstration. The students used LabVIEW to analyse the movement of interference fringes detected by a charge coupled device (CCD) camera and to show in real time the kind of analysis that would allow the detection of energetic gravitational wave events. With the basic idea in place, next year’s students can refine the application for use in scientific outreach.

Micro Project 3—LabVIEW for Secure File Retrieval: Upscaling a Confocal Microscope
Two students restored an optical confocal microscope, which can perform multiple types of microscopy including bright- and dark-field, fluorescence, and differential interference contrast techniques. The system is limited by a 1990s-era controlling PC that cannot connect to the university network. Students designed a system to securely retrieve image files from the controlling PC over the network through an intermediate firewall computer. They used LabVIEW to securely retrieve image files from the controlling PC onto a standard network-connected university PC. The plan for the next academic year is for students to design a scalable GUI application to control the microscope directly.

Micro Project 4—LabVIEW Replacing a Lost Controller Card: Spectrometer Control
A student needed to restore a Czerny-Turner spectrograph. Although the spectrometer and its manual control box were in good condition, the original computer’s controller card was missing (in any case this would have been of little use, being of 1980s vintage). The student used LabVIEW to probe the signals sent from the manual control box to the spectrograph’s motors to specify a control protocol that a modern PC could generate with a myDAQ device. The student developed a prototype control program that could control the scanning optics of the spectrograph and obtain spectra from a modern CCD detector.

Why Use LabVIEW? Why Not Python (or Something Else)?
In principle, we could generate all of the above applications in any of a number of general-purpose programming languages such as Python or C++. However, we would not have enough time to teach

Figure 3. An MSc Physics student implements an NI myDAQ device within a laboratory exercise. NI myDAQ devices can help teach data acquisition, event timing, and automation.
these languages to the level of skill required to produce GUI-driven and hardware-interfacing applications of the same quality produced by the students using LabVIEW.

LabVIEW’s integrated GUI functionality, shallow initial learning curve, high degree of scalability, and ease of integration with hardware such as myDAQ meant that we had more time to instruct students on often neglected coding concepts such as application architectures, design specifications, and good coding style. The latter is particularly important since students must work in groups and collaborate on their code as a cohort.

![Figure 4. To promote best practice in application development, MSc Physics students must critique LabVIEW code, commenting on style, documentation, functionality, and the pros and cons of implementing modifications.](image)

To offer an equivalent course with Python, C++, or a similar language instead of LabVIEW, we would have needed a prerequisite that the student had a high level of programming skill in that particular language. With LabVIEW, we can offer the course with no coding prerequisites whatsoever and still maintain the module’s intended learning outcomes at a master’s level.

With our tightly integrated module design and dedicated teaching space, students can achieve a high level of proficiency in 10 weeks. A student completing the module should be able to efficiently design and effectively write a LabVIEW application with good style to interface with real hardware, implementing an Acquire-Analyse-Present (AAP) or state machine architecture as required.

**Where Next?**
The student feedback for this module and the MSc Physics programme in general has been overwhelmingly positive. Our students recognise the benefits of acquiring a sound working knowledge of programming and project-planning skills in general, and of using LabVIEW in particular. See the following examples of feedback from our MSc Physics students:

“I found the experience of studying LabVIEW through the PXT101 module a useful introduction to learning this programming language. It provides the basic skills to use the software and introduces general programming concepts. These transferable skills can be considered invaluable to a graduate when applying for further study or employment.”
“The LabVIEW programming aspects in PXT101 taught us how to efficiently approach programming tasks methodically by planning out our programs.”

“The feedback we had every week meant that we were constantly given the chance to improve, and I found this to be a far more valuable learning experience than anything I had during my undergraduate degree.”

“I learnt a lot of useful information from PXT101, but the most useful skill I gained from this module was the ability to use LabVIEW. It was a thoroughly enjoyable programming language to learn to use, and has proved extremely useful throughout my MSc course.”

On the basis of multiple student requests, we are in the process of writing an “Advanced LabVIEW Coding for Physics” module designed to run in the spring semester, following on from the solid foundation laid by the core module, “Advanced Experimental Techniques in Physics”. The new module will be available to students starting in the academic year 2016/17.

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