Transitioning MSc Physics Teaching to LabVIEW NXG 2.0: From Drills to DAQ-First
NI Academic Users Forum 2018

Dr Richard James Lewis
Cardiff University School of Physics and Astronomy
MSc teaching at Cardiff University School of Physics and Astronomy

• MSc Physics
• MSc Data-Intensive Physics
• MSc Compound Semiconductor Physics

• MSc Astrophysics
• MSc Data-Intensive Astrophysics

• Two new MScs for 2019/20

Modules with LabVIEW in MSc Physics, DIP, and CSP:

• Advanced Experimental Techniques in Physics (core)
• Advanced LabVIEW Programming for Physicists
LabVIEW content of PXT101 “Advanced Experimental Techniques in Physics”

- PXT101 core for MSc Physics, DIP, CSP
- PXT101 is 20cr, 10cr of which is LabVIEW 2015
- Other 10cr are student-lead micro projects
- *Ab initio* to approximately CLAD standard in 11 weeks
- Very high staff to student ratio
- Stable, mature materials, examples, and projects

- Average student satisfaction score of 93%
- Exceptionally positive student feedback
- Exceptionally positive external examiner feedback
- Engineering Impact Award 2016 (NE, Education)
- Excellence in Engineering Education Award 2017
Example MSc Physics student feedback

- “The way the LabVIEW language was explained definitely improved the total progress I made”

- “Excellent quality teaching supported by good module resources. Good hands-on programming experience.”

- “The coding aspects of the MSc have been insanely useful for my new job.”

- “[LabVIEW] has proved extremely useful throughout my MSc course”
Why would we want to change anything?!

**Pedagogy**
- LabVIEW 2015’s quirks **define** the order of instruction rather than **supporting** it
- Students get to really useful, interesting applications **only in the last third** of the semester
- Interruptions or issues early on can potentially cascade through (**strong scaffolding**)

**Logistics**
- High demands on staff time makes scaling difficult
- Highly tailored examples make sharing and scaling very time- and effort- intensive

**Cohort composition**
- PXT101 will be core for all MScs from 2018/19 onwards (including MSc Astrophysics, MSc DIA)
Why NXG 2.0? Why not 2017?

**Pedagogy (strongly favours NXG)**
- NXG allows a gentler, more logical learning curve
- NXG starts useful and remains useful
- Supporting materials are excellent
- The NXG interface is (much) better
- Language improvements (e.g. G Types)
- Good style is (much) easier to enforce, projects mandatory

**Logistics (no major advantage for NXG over 2017)**
- Most issues here are solved by curriculum design
- Primary requirement is to be relevant and useful
- NXG starting and staying useful allows real-world applications to be tackled throughout
- Possible NXG license / mass install issues?
Pedagogical rationale for transitioning to LabVIEW NXG 2.0
LabVIEW 2015: drills to application

Week 1: projects, front panel, block diagram, dataflow, Express VIs, AAP

Week 2: arrays, clusters, file I/O, case structures, loops, sub VIs, errors, style

Week 3: functional specifications, efficient VI engineering

Week 4: interfacing with hardware, MAX, VISA, AAP with hardware

Week 5: development paradigms, type definitions, DAQmx

Week 6: error handling, tunnels, shift registers, classic state machines

Week 7: event structure, event-driven state machines, functional global variables

Week 8: queues, queued state machines

Weeks 9 to 11: applying LabVIEW to micro-projects
LabVIEW NXG 2.0: DAQ-first, applications throughout (draft)

Week 1: a guided tour of LabVIEW NXG, establishing common and linked contexts

Week 2 (AAV and IO I): no coding required, NXG functionality, DAQ on 1 and 2 channels

Week 3 (AAV and IO II): coding drag and drop, DAQ on 1 and 2 channels, images

Week 4 (AAV and IO III): coding from scratch, DAQ on 1 and 2 channels, images

Week 5 (looping and iteration I): looping and iteration, looping AAV code

Week 6 (looping and iteration II): classic state machines

Week 7 (looping and iteration III): event-driven state machines

Week 8 (looping and iteration IV): queued state machines

Weeks 9 to 11: continuing to apply LabVIEW to micro-projects
How will NXG support MSc learning?

- LabVIEW NXG is useful from day one
- Students can apply NXG throughout
- Concepts are introduced to directly support the learning, rather than being first assembled in abstract form and applied later

**Week 1 (tour)**
- DAQ from myDAQ and cameras, projects
- Explicitly showing how NXG is relevant and useful

**Weeks 2-4 (AAV and IO)**
- Drag-and-drop coding, modifying code, data types, dataflow, sub VIs, flow control, mastering AAV

**Weeks 5-8 (looping and iteration)**
- Loops, spanning arrays, streaming data, open-act-close paradigm, automation, UI-driven apps
### MSc Physics (1 to N channel focus)

<table>
<thead>
<tr>
<th>Week 1</th>
<th>FFT analysis of photodiode data (reaction rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 2</td>
<td>compensating data for temperature variation</td>
</tr>
<tr>
<td>Week 3</td>
<td>gated fluorescence acquisition, integration</td>
</tr>
<tr>
<td>Week 4</td>
<td>consolidate into from-scratch AAV applications</td>
</tr>
<tr>
<td>Week 5</td>
<td>streaming acquisition of IV data, limits of AAV</td>
</tr>
<tr>
<td>Week 6</td>
<td>stepping ((V,T)), streaming (I) data</td>
</tr>
<tr>
<td>Week 7</td>
<td>UI-driven version, dealing with errors</td>
</tr>
<tr>
<td>Week 8</td>
<td>advanced automation and scripting of ((V,T))</td>
</tr>
<tr>
<td>Weeks 9-11</td>
<td>students concentrate on micro-projects</td>
</tr>
</tbody>
</table>

### MSc Astrophysics (1 to N channel focus)

<table>
<thead>
<tr>
<th>Week 1</th>
<th>FFT analysis of light curve data (variable stars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 2</td>
<td>compensating data for temperature variation</td>
</tr>
<tr>
<td>Week 3</td>
<td>gated photometric acquisition, integration</td>
</tr>
<tr>
<td>Week 4</td>
<td>consolidate into from-scratch AAV applications</td>
</tr>
<tr>
<td>Week 5</td>
<td>streaming acquisition of photometric data</td>
</tr>
<tr>
<td>Week 6</td>
<td>stepping ((\theta,\phi)), streaming photometric data</td>
</tr>
<tr>
<td>Week 7</td>
<td>UI-driven version, dealing with errors</td>
</tr>
<tr>
<td>Week 8</td>
<td>advanced automation and scripting of ((\theta,\phi))</td>
</tr>
<tr>
<td>Weeks 9-11</td>
<td>students concentrate on micro-projects</td>
</tr>
</tbody>
</table>

### Key ideas

- Make LabVIEW NXG useful from day one, re-use techniques throughout
- Use real-world techniques / tackle real-world problems each week
- Use linkable concepts from each discipline for each week’s activities
- **Explicitly make the links across disciplines**
- **1 to N channel focus** and **image focus** run in parallel
Logistical rationale for transitioning to LabVIEW NXG 2.0
Common and linked contexts

• Transition from per-student customisation to per-discipline customisation is very scalable

• Possible to address very closely related (or identical) skills and concepts for each discipline at the same time (same assessment)

• Maintains “bespoke” feel for minimum additional organisational effort

• Inherently multidisciplinary: supports peer-learning, collaborative projects, etc.
Use of Core 1, 2 materials, assessment design

Core 1 and 2 on-line materials
- Specify sections of Core 1 and 2 as pre-reading
- Weekly questionnaires linked to the pre-reading
- Aids scalability, reduces assessment load
- NXG Core 3 coming soon?

Other assessment
- Laboratory exercises retained, but now will all be group submissions

Weighting?
- Direct LabVIEW material currently 30% of the course mark – scope for increasing this?
LabVIEW NXG workbooks (embedded in the NXG editor)

These are great – educators really need access to edit these!
Contingency planning and summary
What could go wrong? What’s Plan B?

Potential major issues (showstoppers)
- Split of LabVIEW and NXG licences?
- Issues with NXG mass install / licensing

Short-term pain
- A lot of materials need to be generated
- Need to revise Advanced LabVIEW elective
- Delay / issues with edit access to workbooks?
- No RIO support in 2.0, coming soon? 😞

Plan B
- Adapt PXT101 materials to LabVIEW 2017
- Implement customisation at per-discipline level
Summary: from drills to DAQ-first

• Transitioning from LabVIEW 2015 to LabVIEW NXG 2.0
• Fundamental change to course structure keeps applications central throughout
• Aiming to solve multiple pedagogical and logistical issues simultaneously

• Potential technical issues such as mass installs, split licences, RIO support,
• Workbooks might not become available in time for 2018/19 :(
• Comments, criticism, etc., welcome! :)

www.cardiff.ac.uk/physics-astronomy
Contact details
Dr Richard James Lewis
Director of Postgraduate Taught Studies
School of Physics and Astronomy
Cardiff University

Tel: +44(0)29 2087 5433
Email: LewisR54@cardiff.ac.uk
URL: https://tinyurl.com/y94cfmk5

Case studies, presentations
Bringing the Research Group Ethos into Taught Masters Learning (VICE/PHEC 2016)
MSc Physics Students Take Ownership of their Learning with LabVIEW (NI EIA 2016)
LabVIEW as a Common Language for Community and Skill Building (NI AUF 2016, NIWeek 2017)
Reflections on LabVIEW as a Common Language for Community and Skill Building (NIDays 2017)

www.cardiff.ac.uk/physics-astronomy