



# Experiences with Virtual Learning Environments in Control Engineering Education

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## Structure of Presentation

1. What is Control Engineering ?
2. Control Engineering at DIT Kevin St.
3. Virtual Laboratories
4. Pedagogical Issues
5. Conclusions

### 1. What is control engineering?

*"...if every instrument could accomplish its own work, obeying and anticipating the will of others ... if the shuttle would weave and the pick touch the lyre without a hand to guide them, chief workmen would not need servants, nor masters slaves."*

Aristotle, Politics, Book 1, Chapter 3

[Source: Bennett, S. (1979). "A history of control engineering 1800-1930", Peter Peregrinus Ltd., London]

**Control engineering** is concerned with the understanding and control of machines, processes and industrial automation systems to provide useful economic products for society.

### 2. Control Engineering at DIT, Kevin St.

- **B.E. in Electrical/Electronic Engineering** – Years 2 to 4 (various semesters); electives also available
- **B.E. in Electrical Engineering (part time)**: Final Year (two semesters)
- **B.Tech. in Control and Automation Systems**: Year 3, (elective) – 1 semester
- **B.Sc. in Medical Physics and Bioengineering**: 1 semester
- **M.E. in Advanced Engineering**
- **M.Sc. in Sustainable Energy Management**



### 3. Virtual laboratories

Virtual laboratories are computer based laboratories available on the Web. They are either:

- Simulation based or
- Involve Remote Experimentation

**Example 1** [[www.cheric.org/education/control](http://www.cheric.org/education/control)]



1. Introduction to Process Control
2. Understanding the Measurements: DP cell
3. Understanding the Actuator: Control Valve
4. Feedforward and Cascade Control
5. ....

### Pneumatic Control Valve Installation

The simulation interface includes the following components:

- Control Valve: Controlling Flow Rate**: A schematic showing an input signal (4-20mA) connected to an I/P Transmitter (3-15psi/g), which controls a Valve Opening (0-100%). The valve actuator is connected to a Process, which outputs a Flow rate (0-200 gpm).
- Command Signal**: A graph showing the relationship between Command Signal (mA) and Valve Opening (%).
- Valve Opening**: A graph showing the relationship between Valve Opening (%) and Outlet Flow (gpm).
- Control Panel for Flow Control**: A panel with various parameters and controls:
  - Valve Nature: Hysteresis
  - Valve Actuator: Air-to-Open
  - Characteristic: Installed
  - Process DP (psi): 50psi @ 200gpm
  - Type: ENTER after changing param.
  - Click green # key: [key]
  - Control Panel for Flow Control:
    - Desired Max. Flow: 270.0
    - Pump Discharge P: 34.0
    - Control Valve, Cv: 352.0
    - Rangeability, R: 40.0
- Flow Rate (gpm)**: A graph showing the relationship between Valve Opening (%) and Flow Rate (gpm). It includes curves for Quick Opening, Linear, and Equal Perc.

At the bottom, it states: "You can change the command signal by dragging the pointer. The pump characteristics (head vs. flow) is assumed to be constant."

## Virtual Laboratory - Example 2

Source: <http://www.engin.umich.edu/group/ctm> ; also Messner, W.C. and Tilbury, D. (1999). *Control tutorials for MATLAB and Simulink: a Web-based approach*, Prentice-Hall.

### Tutorials

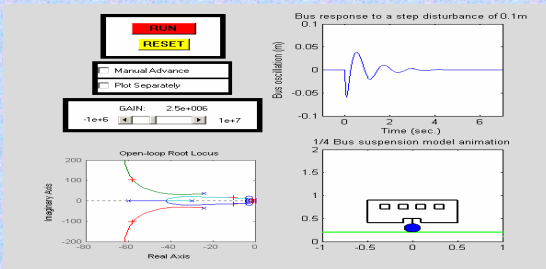
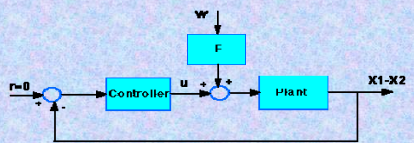
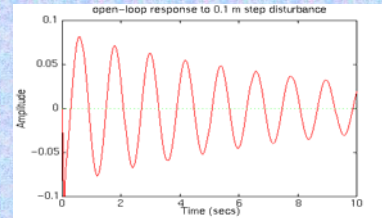
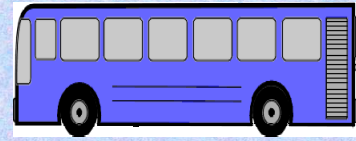
Matlab Basics  
Modeling  
PID  
Root Locus  
Frequency Response  
State Space  
Digital Control

### Examples

Cruise Control  
Motor Speed  
Motor Position  
Bus Suspension  
Inverted Pendulum  
Pitch Controller  
Ball & Beam

Animations Commands Index

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## 4. Pedagogical issues - Why Virtual Laboratories ?

- Duties of the control engineering educator
- Formal classroom and laboratory time is being reduced
- The increasing diversity of student educational background
- The increasing maturity of the tools
- Students increasingly expect technical work which is practical and which motivates independent learning.

## How virtual laboratories have been used

- As backup to a more didactic teaching approach.
- As part of formally assessed assignments.



## Questionnaire

- Virtual laboratories were a beneficial learning experience (compared to other exercises) ?
- Virtual laboratories are user-friendly ?
- The virtual laboratory complements and enhances my understanding of lecture material?
- Virtual laboratories are fun and sustained my interest ?
- I became more interested in the material because of the virtual laboratory viewed ?
- There is enough time to perform the virtual laboratory ?
- I would recommend virtual laboratories to others ?
- Any other comments ?

## Student Feedback - 1

14 replies were obtained (from a total of 17 students).

### Agree

- *Virtual laboratories were a beneficial learning experience (compared to other exercises) – 4.2*
- *Virtual laboratories are user-friendly – 3.9*
- *The virtual laboratories complement and enhance my understanding of lecture material - 4.2*
- *Virtual laboratories are fun and sustained my interest – 3.6*
- *I became more interested in the material because of the virtual laboratories viewed – 3.7*
- *I would recommend virtual laboratories to others – 4.2*

### Unsure

- *There is enough time to perform the virtual laboratories- 3.2.*

## Student Feedback - 2

- Overall, student feedback is encouraging.
- Virtual laboratories increase student motivation, facilitate student self-learning and enhance theoretical understanding and practical ability.
- The experiences gained have shaped the design of the modules in automatic control.
- Assessment methodology has also changed.

## 5. Conclusions

- Twin pressures: the need for students to learn a wider variety of concepts, ideally in a self-learning mode, and the reduction in class contact time.
- From didactic to more learner centered.
- Appropriate use of  
web-based virtual laboratories  
information technology tools, and  
real case studies.
- An improvement in learning outcomes (theoretical understanding, practical ability, motivation, self-learning)
- Further work: Deepen the learner-centered approach.