Development Of An Industrially Relevant Module In A Blended Format: A Practical Approach To Teaching Control

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Introduction and Background

- What?
  - ✓ Developed a new final year elective module based on my research expertise – *integration of research in curriculum*
  - ✓ Practical and industrially relevant module on process control
- Why?
  - ✓ To add on to the basic knowledge and theory on control that students learn in Year 3 - by providing much-needed exposure to practical applications of control
- How?
  - ✓ Blended learning format with flipped classroom and peer instruction
  - ✓ Interactive lectures, hands-on simulation tutorials and in-class activities

Hypothesis

- The traditional process control module is an important part of the chemical engineering curriculum – it introduces the mathematical tools necessary to develop control loops and analyse their performance
  - ➢ But, how does this knowledge translate to industrial control of chemical processes? How are control systems for entire plants developed? How is their performance measured?
  - ➢ Can this new module serve to bridge the gap between control theory and practice?

Methodology

- ***Module syllabus***
  - ➢ Advanced module with syllabus drawn from two books by an internationally renowned expert in this research area (Luyben et al., 1998 and Luyben, 2002)
  - ➢ Some materials based on contemporary research articles and a book on recent developments (Rangaiah and Kariwala, 2011)
- ***Course learning outcomes***
  - ➢ Carefully formulated incorporating all six hierarchies of Bloom's Taxonomy of Educational Objectives
- ***Module structure***
  - ➢ Systematic introduction of a small number of instructional techniques (Felder, 1988)
  - ➢ For example, incorporate short brainstorming sessions or promote active learning by getting students to solve small problems in groups during lecture (Felder et al., 2000)
  - ➢ Team-based learning proven to be effective to promote critical thinking and to better attain the learning outcomes (e.g., Huggins and Stamatel, 2015)
  - ✓ Hence, adopted **flipped classroom approach** and **peer instruction** => active learning facilitated by having student group discussions in groups of 4-5 followed by sharing sessions in class (for example, before every important topic or concept is introduced, as shown in Figure 1 below)

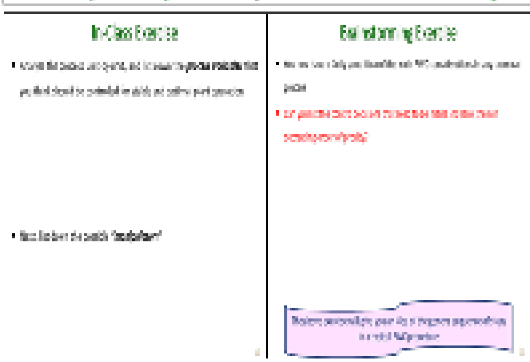

Figure 1: Typical group discussion exercises during the lecture

Figure 2: Typical control system simulation for the project with real-time transient profiles

Methodology (continued)

- ***Module assessment***
  - ➢ 100% continuous assessment (see Figure 3)
  - ➢ Carefully formulated to emphasize class participation and active learning, and to balance individual and group components
  - ➢ Participation graded based on active (vocal) participation in class, response level in live response polls and engagement outside class (emails, consultations, etc.)

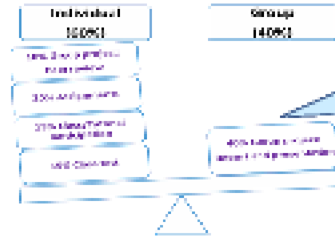

Figure 3: Assessment components for the module

Evaluation

- ***Class size***
  - ➢ Prescribed maximum class size is 40; module has been well received by students that class sizes have been as large as 59
- ***Self evaluation***
  - ➢ Offering a module on practical aspects of control covering dynamic simulation and plant-wide control is perhaps a first in the teaching of the chemical engineering discipline
  - ➢ Students have been very active in class activities and eager to raise questions/issues for discussion
  - ➢ Students have handled the project well – setting up a working dynamic simulation is a daunting task!
- ***Module feedback (selected student comments)***

"Learning a more realistic concept aside from the steady state assumption in the whole 4 years of Chemical Engineering studies which enhances the thinking skills of the students' and the realization of the importance of plant wide control in the industry practice."

"Plantwide control piqued my interest. It gave an introductory view of how a plant is controlled to maintain production objectives and would certainly be useful in my future career."

"Relevant application in future and also acquiring in-depth software skill."

"Content of the module is relevant and up to date by being equipped with knowledge to use HYSYS for dynamic simulations. The delivery of content was well thought and easy to digest. I like the tutorials with the step-by-step guidance and learning."

"The class participation during lecture online questions. The journey of getting from steady state to dynamic is very exciting."

"The content that has been covered is useful and well organized. Lecturer was able to engage the class through the in class discussions."

"Never had I enjoy a TE module as much as this learning. The learning experience is so different in this module. It enhances our team building and technical skill."

- ***Some actions taken based on student feedback***
  - ➢ Use of live response questions in class to gauge the level of understanding of important concepts and address any concerns, and also to promote active student engagement
  - ➢ Break up of the challenging project into three phases (with two short and one long reports) to provide the checks and balances that ensure students make reasonable progress

Conclusions

- Curriculum innovation
  - ✓ An innovative technical elective module in the field of process systems engineering to complement the theory-based control module
- Active learning
  - ✓ Techniques such as class discussions and live response questions
  - ✓ Engaging classroom by giving students numerous opportunities to participate and speak
- Module evaluation
  - ✓ Overwhelming subscription to the module
  - ✓ Students' active participation in class activities
  - ✓ Positive comments in student feedback

References

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