Bridges for Engineering Education – Virginia Tech (BEEVT)

A group of engineering and education faculty received a planning grant BEEVT in 2003 from the NSF. One key objective was to:

*create a contemporary framework for undergraduate engineering pedagogy, beginning with freshman engineering experiences*

BEEVT investigators proposed a spiral curriculum approach and received an implementation grant in 2004 under the Department-Level Reform (DLR) program of NSF.
Reformulating General Engineering and Biological Systems Engineering Programs at Virginia Tech

NSF/DLR Project: $1,082,944; September 2004 – August 2009

Participating Faculty
Engineering Education (6)
Biological Systems Engineering (5)
School of Education and Academic Assessment (1)
Civil and Environmental Engineering (1)
Mining and Minerals Engineering (1)
Computer Science (1)

Students
Six PhD students: BSE (2), Psychology (1), School of Education (1), CEE (1), and ENGE(1)
Two MS students: BSE
Six Undergraduate students: CEE, EE, CPE, and BSE

International Component of NSF-DLR Project
Collaboration with National Cheng Kung University, Taiwan

Goal of the NSF/DLR Project

To undertake department-level reform (DLR) of the General Engineering (GE) and the Bioprocess Engineering Option within the Biological Systems Engineering (BSE) Department at Virginia Tech.
Spiral Curriculum – General Concepts

Jerome Bruner and the Spiral Curriculum - A Quick Introduction

• Leading educational theorist of the 20th century
• Focus on learning and construction of meaning
• Emphasis on curriculum as a vehicle for student development
Basic Elements of the Spiral Concept

- Authentic engagement from the beginning
- Thematic curricular organization
- Periodic revisiting of key topics and themes
- Increasing complexity with support
- Student mastery of learning process

Advantages of Spiral Curriculum

- Allows an “honest” introduction to any domain of interest
- Provides a framework for moving learning to higher levels of representation and inclusiveness
- Preserves thematic integrity within the curriculum
Spiral Curriculum Development in Biological Systems Engineering


Steps in Curriculum Design

1. Identify outcomes to be achieved by the students upon graduation
Outcomes Identified for Bioprocess Option in BSE

• A bioprocess engineer should be able to:
  – Design a reactor
  – Design a process and optimize the process conditions
  – Select units in the process and design a plant layout
  – Control the process

Steps in Curriculum Design

1. Identify outcomes to be achieved by the students upon graduation

2. Develop concept maps to identify knowledge required to master each outcome
Spiral Concepts for Reactor Design

Concept Map for Reactor Design

- Ethics
- Economics
- Process parameters
  - Mass/Energy/Momentum balances
  - Chemical reactions
    - Stochiometry and process kinetics
- Environmental impacts
- GMP
- Safety
- Process Control
  - Materials handling
    - Raw Materials
    - Biology
    - Material Properties
  - Intermediate materials
  - Waste
Steps in Curriculum Design

2. Develop concept maps to identify knowledge required to master each outcome

3. Identify knowledge acquisition required for each outcome at different levels in the spiral curriculum

Unit Operations

- **Mechanical**
  - Size reduction
  - Sieving
  - Filtration
  - Centrifuge

- **Thermal**
  - Evaporation: II & III
  - Distillation
  - Drying: spray, drum, freeze, thin layer, deep bed, fluidized bed
  - Heat Exchangers: types, design and selection
  - Flash Cooling
  - Fluidization: III & IV
  - Sterilization
  - Pasteruization
  - Freezing
  - Cryogenics: IV

- **Mass Transfer**
  - II & III Extraction
  - Precipitation
  - Membrane separations
  - Crystallization
  - Absorption
  - Adsorption
  - Chromatography
  - Leaching
  - III & IV Stripping

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**Unit Operations**

- **Mechanical:** Size reduction, filtration, centrifuge, agitation
- **Thermal:** Distillation, drying
- **Mechanical – size reduction, sieving, filtration, centrifuge, cyclone, sorting**
- **Thermal – Distillation, drying, fluidization, sterilization, pasteurization, heat exchangers, flash cooling**
- **Mechanical – cyclone, sorting**
- **Thermal – Fluidization, sterilization, pasteurization, freezing, chilling, heat exchangers, cryogenics, flash cooling**

**Steps in Curriculum Design**

3. Identify knowledge acquisition required for each outcome at different levels in the curriculum

4. Develop learning objectives for each knowledge level and outcome
Design a Process – Level II

Learning Objectives
• Explain and demonstrate a process
• Identify and describe the parameters affecting a process
• Perform mass balance
• Understand some basic principles related to bioprocess engineering

Design a Process – Level III

Learning Objectives
• Understand the principles and applications of various unit operations
• Identify appropriate unit operations for a given task
• Design a unit operation to achieve a given task
• Perform advanced mass balance for unit operations
• Perform energy balance for unit operations
• Evaluate the economics of unit operations
Design a Process – Level IV

**Learning Objectives**
- Design a complete process
- Draw complete process flow sheets
- Perform overall mass and energy balances
- Optimize process conditions
- Perform economic analysis for processes

Steps in Curriculum Design

4. Develop learning objectives for each knowledge level and outcome

5. Develop learning modules consisting of problems/projects/activities to facilitate student achievement of the objectives
Learning Module (Cont’d)

Learning activities

• **In-class presentation** – to give context for the terminology
• **In-class group activity** – each group identifies systems
• **In-class introduction** – to laboratory exercises
• **In-class group activity** – compile examples and discuss
• **Group laboratory exercises** – conduct “Extraction and Refining of Cottonseed Oil” exercise and “Hydrologic System” exercise
• **Individual homework and group laboratory report**
• **Individual assessment of student knowledge** – post laboratory exercise

Steps in Curriculum Design

5. Develop learning modules consisting of problems/projects/activities to facilitate student achievement of the objectives
6. Incorporate the learning modules into existing courses (or)
7. Develop new courses to include the learning modules
In Summary

1. Identify outcomes to be achieved
2. Develop concept maps
3. Identify knowledge for each outcome at different levels
4. Develop learning objectives
5. Develop learning modules
6. Incorporate the modules to existing courses
7. Develop new courses to include the modules
Extension of Spiral Work to Engineering Science & Mechanics (ESM) Department


Nanotechnology Option Using Spiral Curriculum Approach – ESM Department

NSF/NUE project: 2008-10 (ESM, ICTAS, EngE faculty)
Extension of Spiral Curriculum Work to Coverage of Professional Ethics


Graduate Interdisciplinary Liberal Engineering Ethics Curriculum (GILEE)

http://www.esm.vt.edu/~ikpuri/ethics/gilee.html

Graduate Course: Global and Ethical Impact of Emerging Technologies

Summer Workshop
June 8-9, 2009
Ethics Class Project - Examples

Spiral Curriculum Extension to ME, MSE, ESM

(slides will be added)