Design of Pedagogy Courses for Graduate Students and Beginning Faculty

Faculty Issues on Engineering Education I

Session 12a5, Ashford Room

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Why Pedagogy Courses? What are The Forces Driving These Changes?

What is the Current Status of Courses in Teaching Engineering?

What are Some Approaches for Designing These Courses?

Some Forces Driving These Changes

- NSF - Career Development Award & Shaping the Future
- ABET
  - Assessment
  - Synthesis & Design
- Employers
- University Administration
- Boyer Commissions - Educating Undergraduates in the Research Universities &Scholarship Reconsidered
- Educational Research
  - Active, Interactive & Cooperative Learning
  - Inquiry

Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology 1996 Report to the NSF

Goal – *All students have access to supportive, excellent undergraduate education in science, mathematics, engineering, and technology, and all students learn these subjects by direct experience with the methods and processes of inquiry.*

<u>Institutions of Higher Education</u>

We recommend that:

● *SME&T faculty:* Believe and affirm that every student can learn, and model good practices that increase learning; starting with the student's experience, but have high expectations within a supportive climate; and build inquiry, a sense of wonder and the excitement of discovery, plus communication and teamwork, critical thinking, and life-long learning skills into learning experiences.

● *SME&T departments*: Set departmental goals and accept responsibility for undergraduate learning, with measurable expectations for all students, offer a curriculum engaging the broadest spectrum of students; use technology effectively. . .

Accreditation Board for Engineering and Technology
Engineering Criteria 2000

Criterion 3. Program Outcomes and Assessment

Engineering programs must demonstrate that their graduates have

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs

(d) an ability to function on multi-disciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Employer's Checklist — Boeing Company

- A good grasp of these engineering fundamentals:
  - Mathematics (including statistics)
  - Physical and life sciences
  - Information technology
- A good understanding of the design and manufacturing process (i.e., an understanding of engineering)
- A basic understanding of the context in which engineering is practiced, including:
  - Economics and business practice
  - History
  - The environment
  - Customer and societal needs
- A multidisciplinary systems perspective
- Good communication skills
  - Written
  - Verbal
  - Graphic
  - Listening
- High ethical standards
- An ability to think critically and creatively as well as independently and cooperatively
- Flexibility--an ability and the self-confidence to adapt to rapid/major change
- Curiosity and a lifelong desire to learn
- A profound understanding of the importance of teamwork

Michigan State University Guiding Principles

Six Guiding Principles were established by the university in 1994 to guide MSU into the next century. We will:

- Improve Access to Quality Education and Expert Knowledge
- Achieve More Active Learning
- Generate New Knowledge and Scholarship Across the Mission
- Promote Problem Solving to Address Society's Needs
- Advance Diversity within Community
- Make People Matter

Peter McPherson, President

Reinventing Undergraduate Education:
A Blueprint for America's Research Universities

The Boyer Commission on Educating Undergraduates
in the Research Universities, April 1998

Ten Ways to Change Undergraduate Education

Make Research-Based Learning the Standard
Construct an Inquiry-Based Freshman Year
Build on the Freshman Foundation
Remove Barriers to Interdisciplinary Education
Link Communications Skills and Course Work
Use Information Technology Creatively
Culminate with a Capstone Experience
Educate Graduate Students as Apprentice Teachers
Change Faculty Reward Systems
Cultivate a Sense of Community

http://notes/cc.sunysb.edu/Pres/boyer.nsf

Current Status of Courses in Teaching Engineering

- ASEE 1998
  - Session 1655 - Excellence in Teaching at the Graduate Level
  - Session 0455 - Graduate Student Session
- ASEE Prism, May-June 1999
- Smith & Kritskaya Survey
- FIE 1999
  - Session 13a8 Engineering Education Scholars Workshops
  - Session 13d4 College-Based Programs for Enhancing Teaching and Learning

Types of Teaching Training

ASEE Prism, May-June, 1999

- Training While in School – 45%
- In-house/On-campus – 50%
- Off-campus Workshops/Seminars – 40%
- Teaching Mentor – 25%
- Other – 7%
- No Training at All – 20%

Smith & Kritskaya Survey

- Literature Search
- Request posted to Tomorrow's Professor ListServe
- Informal Contacts

Summary of Survey Results

- Detailed Materials (Syllabi, etc.) From 14 Courses
- Mix of Courses for:
  - Graduate students
  - Faculty
  - Engineering, Science & General
- Content Analysis
  - Format
  - Pedagogy

Format and Pedagogy

- Format:
  - Course title, disciplines, participants, credits, grading, references
- Pedagogy
  - Course Objectives
  - Topics
  - Projects and Activities
  - Teaching/Learning Strategies
  - Emphasis on Research

College Teaching in Engineering

Gustafson – Ohio State

1. Historic perspectives in teaching engineering
2. Learning styles
3. Lecture/Presentation styles
4. Bloom's taxonomy/Cognitive levels of learning
5. Alternatives to traditional lecture
6. Teaching non-traditional students
7. Evaluation of student learning and instruction

College Teaching in Engineering

Gustafson – Ohio State

1. Class discussion and analysis of readings
2. Brief written summaries on readings
3. Developing a teaching philosophy statement early in the course and refining it throughout
4. Micro-teaching – 10-15 minute session with peer feedback

Kritskaya Reflection

- Informative not Transformative
- Procedurally Oriented not Conceptually Oriented
- Individually Focused not Team Focused
- . . .

Course Design

- Diamond – *Designing & Assessing Courses and Curricula*
- Wiggins & McTighe – *Understanding by Design*
- Leifer – Engineering Design
- Felder & Brent – Course Design

Diamond – Basic Design Sequence

- Statement of Need
- Statement of Goals
- Design of
  - Instruction
  - Assessment
- Implementation and Assessment
- Revision as Needed

Wiggins & McTighe – Understanding by Design

- Design (vb) – To have purposes and intentions; to plan and execute (Oxford English Dictionary)
- Backward Design
  - Conceptual framework, design process, and accompanying set of design standards
  - A way to design or redesign any curriculum to make student understanding more likely

Backward Design

Stage 1. Identify Desired Results

Stage 2. Determine Acceptable Evidence

Stage 3. Plan Learning Experiences and Instruction

Backward Design

Stage 1. Identify Desired Results

Filter 1. To what extent does the idea, topic, or process **represent a "big idea" having enduring value beyond the classroom?**

Filter 2. To what extent does the idea, topic, or process **reside at the heart of the discipline?**

Filter 3. To what extent does the idea, topic, or process **require uncoverage?**

Filter 4. To what extent does the idea, topic, or process **offer potential for engaging students?**

Backward Design

Stage 2. Determine Acceptable Evidence

Types of Assessment:

Quiz and Test Items: Simple, content-focused test items

Academic Prompts: Open-ended questions or problems that require the student to think critically

Performance Tasks or Projects: Complex challenges that mirror the issues or problems faced by graduates, they are authentic

Backward Design

Stage 3. Plan Learning Experiences and Instruction

- What enabling knowledge (facts, concepts, and principles) and skills (procedures) will students need to perform effectively and achieve desired results?
- What activities will equip students with the needed knowledge and skills?
- What will need to be taught and coached, and how should it be taught, in light of performance goals?

Inquiry Learning Cycle
BSCS

- Engage
- Explore
- Explain
- Evaluate

The Students Explain[1]

1. In trying to make their thoughts clear for other people, student achieve greater clarity for themselves.

2. The students themselves determine what it is they want to understand.

3. People come to depend on themselves.

4. Students recognize the powerful experience of having their ideas taken seriously, rather than simply screened for correspondence to what the teacher wanted.

5. Students learn an enormous amount from each other.

6. Learners come to recognize knowledge as a human construction, since they have constructed their own knowledge and know that they have.

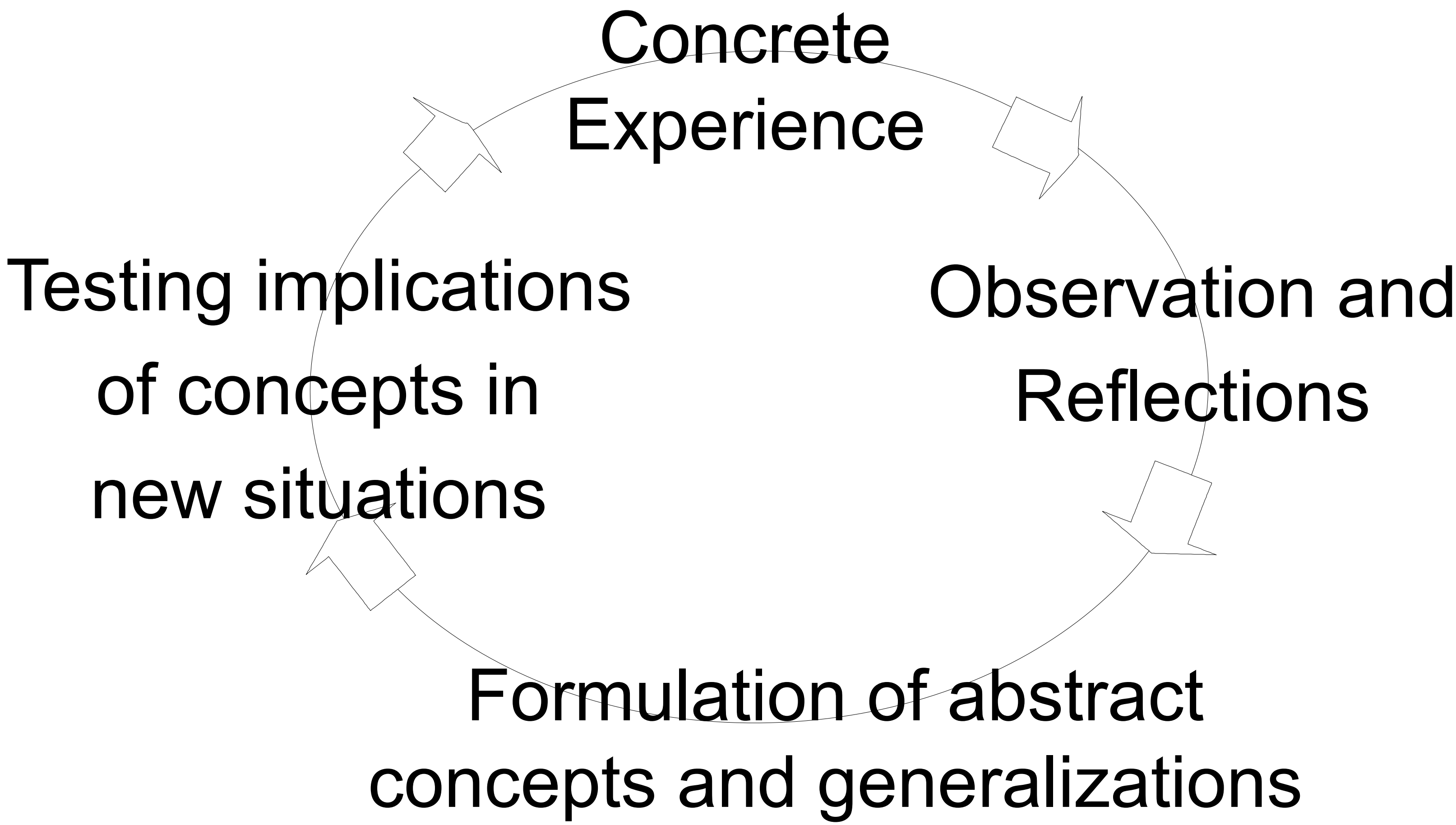
[1]Duckworth, E. 1987. *The having of wonderful ideas" & other essays on teaching and learning*. New York: Teachers College Press.

Leifer – Stanford

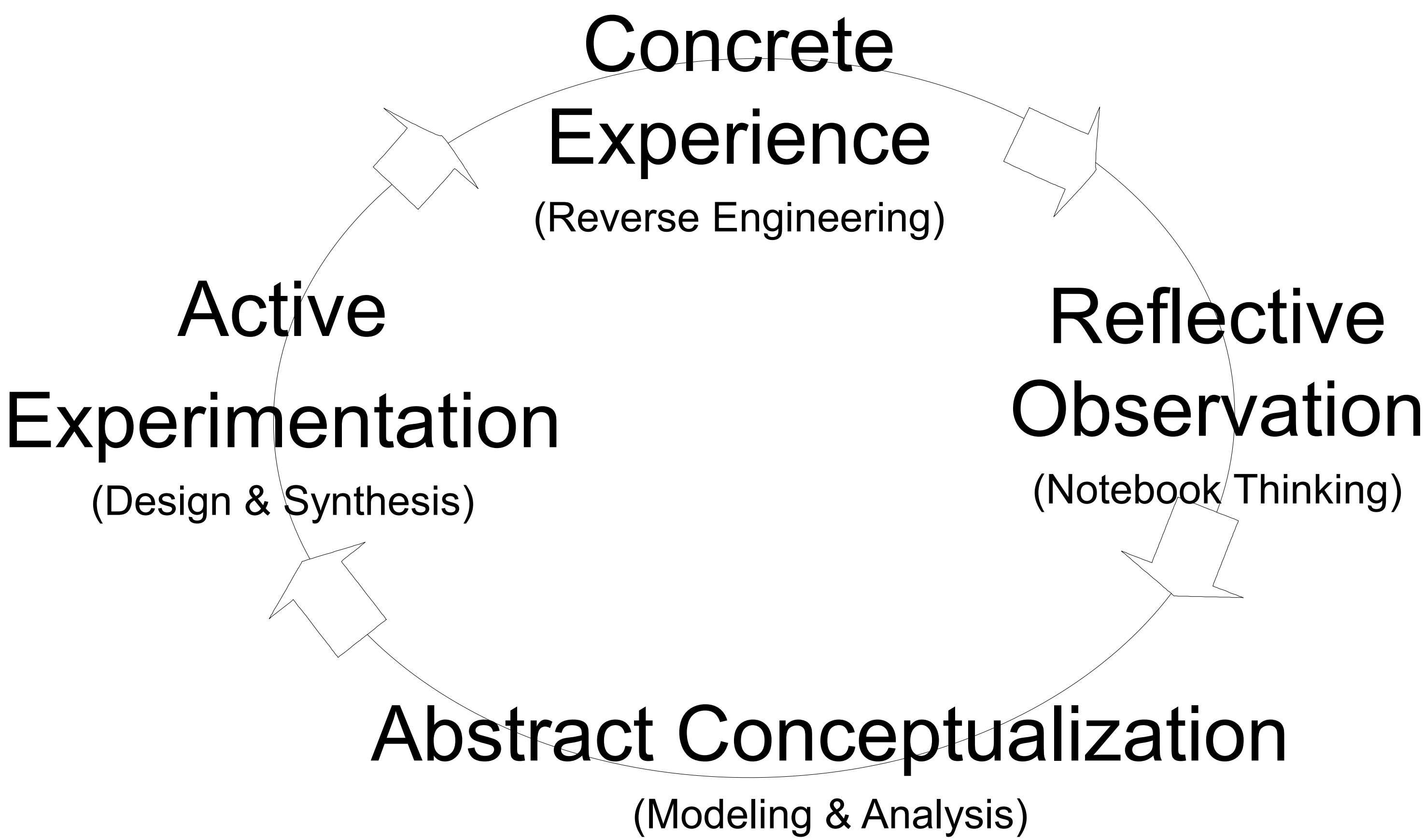
Design – A social process that identifies a need, defines a problem, and specifies a plan that enables others to manufacture the solutions

Engineering Education – A social activity that identifies a need, defines a pedagogical problem and specifies a curriculum that enables others to learn from experience

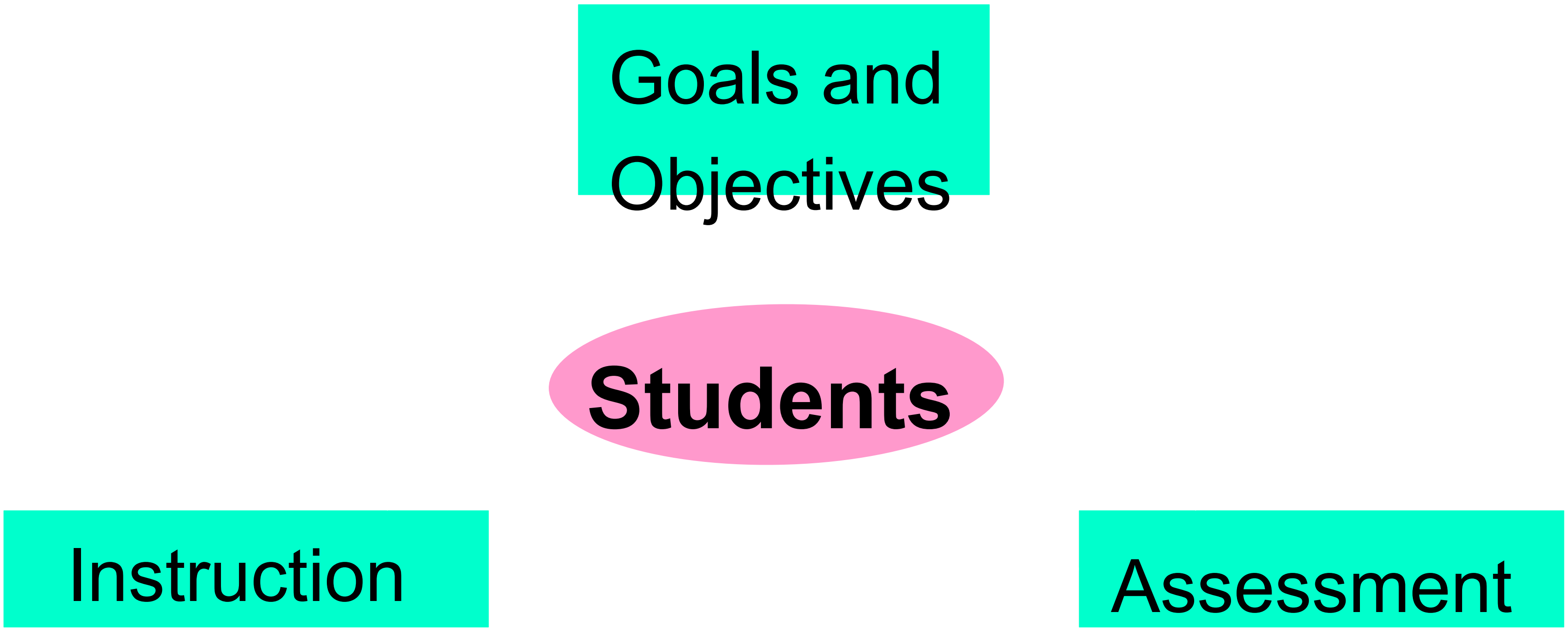
Kolb's Experiential Learning Cycle



Product-Based Learning
Leifer (Stanford)



Effective Course Design



FIE99 – Session 13b7
Engineering Practice and Textbook Design

Sheri Sheppard, Laura Demsetz & Joseph Hayton

"Isn't the design and development of an engineering textbook just another engineering project?"

“Isn’t the design and development of an engineering course just another engineering project?”