Laboratory Teaching

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Teaching College-Level Science and Engineering
# Goals of Laboratory Courses

- Obtain experimental skills
- Familiarize with equipment
- Learn to build, construct

- Communicate
- Net work
- Work in teams
- Review Independent learning

- Discover
- Observe
- Manipulate
- Motivate

## Skills

## Knowledge

## Understanding
Laboratory Teaching: To Do or Not To Do?

Mc Keachie, 1994

- No advantage compared to other methods of teaching in terms of amount of information learnt

BUT

- There are differences in retention, ability to apply learning, skills development, material manipulation

Issues

- Studies performed a long time ago (1930s-1970s)
- No description of laboratory style
Research Update

Hofstein, Lunetta, 2002

- Shortcomings in methodology of science education labs (1982)
  - Control over procedures
  - Reports of instructional and assessment procedures used
  - Assessment measures of students learning outcomes vs goals of teaching and research
  - Sample size

  - Learning by inquiry
  - Importance of defining inquiry

Different Styles
## Different Styles of Laboratory Teaching

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Expository Style of Instruction

WHAT?

Instructor
Defines topic
Relates subject to previous work
Directs students’ actions

Students
Follow instructions-cookbook
Collect data
Compare with expected outcome

WHY?

Large number of students-Minimal teacher participation
2-3 hrs time spam-Low cost

CRITICISMS

Emphasizes lower-level cognitive skills (know, comprehend, apply)
Excludes higher-level cognitive skills (analyze, synthesize, evaluate)
Inquiry Style of Instruction

WHAT?
Students
Formulate problem
Relate topic to previous work
State purpose
Predict results
Identify procedure
Perform investigation

WHY?
Mimics scientific inquiry
Improves attitude towards science and critical thinking
Emphasizes higher-level cognitive skills (hypothesize, explain, criticize, analyze, invent, evaluate)

CRITICISMS
Assume operational thought but not develop it
Too much demand on students’ short term memory
Too much emphasis on scientific process and not content
Discovery Style of Instruction

WHAT?

Instructor
Provides procedure
Guides students towards discovery

Students
Generate questions
Collect data
Draw conclusions

WHY?

Learn by direct experience
Develop understanding of principles

CRITICISMS

Time consuming
Not transferable strategies across disciplines
How can students discover if they are not conceptually prepared?
Problem-Based Style of Instruction

WHAT?

Instructor
Introduces topic-assigns readings
Answers questions
Offers suggestions

Students
Gather info from readings
Design experiment
Solve a given problem

WHY?

Helps develop testable hypotheses rather than obtain correct results
Models real-life investigations
Creates successful problem solvers and critical thinkers

CRITICISMS

Time consuming
Places greater demand on students and instructor
Must have had exposure to concept or principle before experiment
Decisions To Be Made

- Lab organization
  - □ Stand alone (separate course)
  - □ Coordinated (topics in lab and lecture are studied at the same time)
  - □ Integrated (results in lab are used in lecture)

- Team or individual work

- Student assessment-evaluation
  - □ Quizzes, oral presentation, report
  - □ Evaluate teams and individuals

- Records

- Equipment quality

- Feedback process
Constraints Under Consideration

- Learning Objectives
  - Low or high cognitive skills
  - Year in school (freshmen vs seniors)
- Teaching staff
- Facilities-equipment
- Time period
- Cost
- Politics (all sorts)
How About the Future?

- Use of technology
  - Improved equipment, facilities
  - Remote access to experimental processes
    - [http://icampus.mit.edu/ilabs/](http://icampus.mit.edu/ilabs/)
- Re-invent laboratory courses?
- Ideas?