



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

Skills

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

Knowledge

- Discover
- Observe
- Manipulate
- Motivate

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
- New standards (2002)
 - Learning by inquiry
 - Importance of defining inquiry

Different Styles

Different Styles of Laboratory Teaching

Style	Descriptor		
	Outcome	Approach	Procedure
Expository	Predetermined	Deductive	Given
Inquiry	Undetermined	Inductive	Student generated
Discovery	Predetermined	Inductive	Given
Problem-based	Predetermined	Deductive	Student generated

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/>
- Re-invent laboratory courses ?
- Ideas ?