Stimulating student learning in multiple dimensions through introductory laboratories

AAC&U Meeting - New Orleans - Friday, Jan. 19, 2007

Panelists:

- Dave Grosnick (Physics & Astronomy - Ball State Univ.)
- Christopher Hight (Architecture - Rice Univ.)
- Laura Blasi (Assessment & Institutional Research – St. Leo Univ.)
- Robert Swanson (Biology - Valparaiso Univ.)
- Gary Morris (Physics & Astronomy - Valparaiso Univ.)
Act I
Busy faculty prepare for overwhelmed freshmen
Students and faculty battle limited resources.
Dissatisfaction with introductory labs abounds.
Intro labs are proving grounds for creativity and learning.
Innovations stimulate learning in multiple dimensions.
Act II, Scene 1
The Intro Physics Laboratory Experience at Ball State University

David Grosnick
Department of Physics and Astronomy
Ball State University

2007 AAC&U Meeting
January 19, 2007
Introductory Physics
Laboratory Goals

Develop Experimental and Analytical Skills
Use equipment, computers to collect, analyze, graph data

Enhance Conceptual Learning
Master concepts through direct observation

Encourage Collaborative Learning
Work in pairs, groups to complete experiment, brainstorm

Communicate Results and Achievements
Summarize, conclude results by written and oral means
What can be done?

*Guided inquiry*
Allow students to discover phenomena by themselves (with some assistance)

*Studio format*
Arrange laboratory setting to maximize learning using collaborative groups of 2-4 persons

*Technology*
Use computer-based data acquisition (probes and sensors) and perform data analysis with spreadsheets

Use learning cycle: prediction, observation, comparison, analysis, and quantitative experimentation
Examples of Intro Physics Labs

Technology

Experiment design

Explaining motion

Computer simulations
Important to understand class

Demographics
Who are your students?
Class, majors, backgrounds

Knowledge
What have they learned (or not)?
Assessment instruments, correlations

Attitudes
What do the students think?
Surveys, evaluations, feedback

Can Adapt to Students’ Needs
Demographics

Student Majors in Algebra-Based Intro Physics


Algebra Based Physics

1st semester

- Biology 20%
- Technology 19%
- Pre-Pharmacy 3%
- Pre-Med/Dent/Vet 22%
- Med Tech/Rad Tech 6%
- Exercise Sci/Athletic 8%
- Education 4%
- Chemistry 5%

742 students
Introductory Physics Student Class

177 Students

Sophomore 33%
Junior 33%
Senior 16%
Graduate 4%
Other/Not given 2%
Freshman 12%

Calculus-Based (1st Semester)
Mostly frosh and sophomores

Algebra-Based (1st Semester)
Mostly juniors and sophomores
Correlation with High School Physics

Algebra-Based Introductory Physics  (2003-2005)

742 students

Final student grades

Observe shift of about 1/2 grade
Student Learning Assessment

• Use “standardized” assessment instruments

Example: Force Concept Inventory (FCI)

30 conceptual questions on motion
Written in everyday language
Perform pre- and post-test assessment

• Other assessment methods
Example: A large truck collides head-on with a small compact car. During the collision:

<table>
<thead>
<tr>
<th>Answers (paraphrased)</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Truck exerts greater force on car</td>
<td>74.7%</td>
<td>37.4%</td>
</tr>
<tr>
<td>B. Car exerts greater force on truck</td>
<td>1.1</td>
<td>2.6</td>
</tr>
<tr>
<td>C. Neither exerts force on other</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>D. Truck exerts force on car, not vice versa</td>
<td>1.3</td>
<td>0.9</td>
</tr>
<tr>
<td>E. Truck and car exert same force</td>
<td>22.4</td>
<td>58.4</td>
</tr>
</tbody>
</table>

Increase of 36 % pts. in correct responses, and overall ~60% correct

Similar questions in lab to improve conceptual learning
Use of Personal Response System in Lab

- More practice with conceptual questions
- Introduction to lab ideas
Personal Response System Method

1. Read and respond to question
2. Observe results
3. Collaborative learning
4. Re-respond to question
5. Results
6. Review explanation

Results: Under scrutiny
Benefit: Get students “prepped” and thinking about lab
Conclusions and Summary

Lab goals: expt’l and analytical skills, conceptual and collaborative learning, communication

Use: guided inquiry, studio format, and technology

Important to understand students in class: look at demographics, knowledge, and attitudes

Can adapt to students’ needs

Can use natural curiosity to stimulate student learning

Need for science literacy
Act II, Scene 2
Scientists are like architects who build buildings of different sizes and shapes and who can be judged only after the event, i.e., only after they have finished their structure. It may stand up, it may fall down—nobody knows.

—Paul Feyerabend, Against Method
15 Minutes
The image of creative activity

• The image of the heroic genius

• Creative acts as the opposite of science and methodical research.

• The cliche that architecture is a synthesis of art and science.
Liberal Education, Professional Training or Academic Research? Architectural Education as Model

- The identity of the architect is changing as the disciplines reconfigure around new conditions of the contemporary environment and economy
- Should the 19th model change as well?
- Lab versus studio
What architectural education is, where it has been, where it might be.

- MIT, 1868
  - the first degree-granting school of architecture in the United States 1932

- Architectural Association, London, 1864
  - an “endeavor towards an improved system of architectural study”
Architectural education is primarily lab based and intensely so.
45 Minutes
15 Minutes
Architectural Laboratory is:

- **Problem Based**
  - Combines analytical and synthetic forms of research and learning
  - Integrates broad and diverse competency and knowledges through the specifics of an issue, a question, or a problem
- **Does not simply problem solve, but shows how problems are formulated**
  - Not just about gaining competency but providing tools for innovation
- **Mediated, Instruments!**
Multi-Modal Learning
drawing, model making, reading, writing, talking
Format of Instruction
individualized tutorials, group presentations, student
professor sets frameworks, guides processes
45 Minutes
Architectural practices of research through design

• Architectural Labs do not teach “architecture” as a body of knowledge so much as inculcate the student into the culture of architecture.

• Through the studio one learns how to be an architect.
  – this is an ethical model of education
  – the goal is not learning a rule set, or a method, though these can be instrumental
15 Minutes
Fostering Collective Intelligences
Information technology allows the development and transfer of ideas and research.

All work is done in teams that reconfigure and work through media.
“Virtual” Laboratories, Real Communities
45 Minutes
Establishing critical and independent thought by understanding the structures through which one innovates thought and practice.
Act II, Scene 3
Laura Blasi
Assessment & Institutional Research

Click Here
Act II, Scene 4
Rob Swanson
Peer instruction and evaluation in biology lab
Taking an academic discipline and expanding its significance

- The problem with purely academic pursuits
- The burden of proof rests now with the students
- The outcome should be judged by peers, changing the dynamic of the project
Establish learning goals for the exercise

– Physiology/Morphology
– Role in ecosystem
– Role in human affairs
– Audio presentation
Using peer pressure and legacy to increase quality of scholarship

Legacy component: Recordings passed from one year to the next.
Flexible Evaluation

- Quiz
- Reflection on impact on human society
Faculty observe enhanced quality and engagement
Act II, Scene 5
Physics lab promotes multiple dimensions of learning.

1. Concrete Experience
2. Observation & Reflection
3. Form Abstract Concepts
4. Test in New Situations

Gary.Morris@valpo.edu
15 Minutes
Following the Kolb learning promotes liberal learning.

1. Concrete Experience
2. Observation & Reflection
3. Form Abstract Concepts
4. Test in New Situations
45 Minutes
Tower building introduces Kolb Learning cycle.
Non-threatening intro activity promotes collaborative culture
Discuss specific activities in lab, then extrapolate.
Lab learning objectives fulfill liberal education goals.
45 Minutes
Discussions promote critical thinking & logical dialogue.
Written reports require synthesis and self-evaluation

- I need to be more assertive.
- I want to learn Excel.
- After this lab exercise, I finally understood error analysis.
Reshuffling lab partners maintains collaborative culture
15 Minutes
Faculty reflect on the strengths and weaknesses.
45 Minutes
Faculty see enhanced student collaboration and teamwork.
Multi-week exercises enhance student innovation & learning.

<table>
<thead>
<tr>
<th>Tentative Menu of Laboratory Exercises</th>
<th>Date (Week of)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Lab (first week of class)</td>
<td>Aug. 21</td>
</tr>
<tr>
<td><strong>Unit 1: Gravity – Report Due week of 10/2</strong></td>
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<tr>
<td>1.1. Introduction to Laboratory</td>
<td>Aug. 28</td>
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<tr>
<td>1.2. Measuring the Acceleration of Earth’s Gravity</td>
<td>Sept. 4</td>
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<tr>
<td>1.3. Earth’s Gravity Revisited</td>
<td>Sept. 11</td>
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<tr>
<td>1.4. One-Dimensional Motion</td>
<td>Sept. 18</td>
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<tr>
<td>1.5. Projectile (Two-Dimensional) Motion</td>
<td>Sept. 23</td>
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<tr>
<td><strong>Unit 2: Newton’s Laws – Report Due week of 10/23</strong></td>
<td></td>
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<tr>
<td>2.1. Free-Body Diagram Workshop</td>
<td>Oct. 2</td>
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<tr>
<td>2.2. Force and Acceleration</td>
<td>Oct. 9</td>
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<tr>
<td>2.3. Uniform Circular Motion</td>
<td>Oct. 16</td>
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<tr>
<td><strong>Unit 3: Conservation Laws – Report Due week of 12/4</strong></td>
<td></td>
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<tr>
<td>3.1. Work – Energy Theorem</td>
<td>Oct. 23</td>
</tr>
<tr>
<td>3.2. Work Done and Change in Kinetic Energy</td>
<td>Oct. 30</td>
</tr>
<tr>
<td>Work Done and Change in Kinetic Energy (Con’t)</td>
<td>Nov. 6</td>
</tr>
<tr>
<td>No Lab (Special Physics Lecture)</td>
<td>Nov. 13</td>
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<tr>
<td>No Lab (Thanksgiving Break)</td>
<td>Nov. 20</td>
</tr>
<tr>
<td>3.3. Collisions and Conservation Laws</td>
<td>Nov. 27</td>
</tr>
<tr>
<td>4. Make-up lab (TBD)</td>
<td>Dec. 4</td>
</tr>
</tbody>
</table>
Less is more.
Physics lab promotes multiple dimensions of learning.

1. Concrete Experience
2. Observation & Reflection
3. Form Abstract Concepts
4. Test in New Situations

Gary.Morris@valpo.edu
Act III
Can innovative labs inspire and promote liberal learning?
Traditional labs often frustrate both students and faculty.
Liberal learning objectives improve lab efficacy.
Promoting liberal learning through innovative intro labs.
Labs can enrich student & faculty experiences.
Stimulating student learning in multiple dimensions through introductory laboratories

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