

# 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.)

Welcome and thank you for your interest in our panel discussion. Today we'll explore the role introductory laboratories can play in liberal, undergraduate education. Our panel represents a broad range of disciplines: Rob Swanson is from the Biology Dept. at VU. Dave Grosnick is from the Physics & Astronomy Dept. at Ball State Univ. Christopher Hight is from the School of Architecture at Rice U. Laura Blasi is from the [Education Dept. at U. Central Florida](#). And I'm Gary Morris from the Physics & Astronomy Dept. at Valparaiso Univ. I thank my panelists for their contributions and look forward to a very interesting, broad ranging discussion of introductory laboratory models. At the end, I hope there will be time for you to contribute your responses and ideas. Let me start by providing a brief context and motivation for our session.



## Busy faculty prepare for overwhelmed freshmen

The beginning of the school year is a frantic time of stress and renewal. As we approach the beginning of the semester, whether faculty members, returning underclassmen, or freshmen, we are faced with an array of responsibilities, surprises, and expectations. Freshmen arrive at our institutions with great hope and promise, and generally open minds about the experiences which we, as their teachers, craft in part for them. I dare say, sometimes (and perhaps frequently), we fall into the trap of repeating the “tried and true” practices we’ve implemented for years -- at least in part because it takes less effort on our parts. But in so doing, we pass up an opportunity unique in our students’ college experience, to engage and challenge our students with interesting and even enjoyable introductory activities that build a positive community of learners.



In crafting new activities, however, we are limited by the time available to us and the financial resources of typically limited budgets. Our students are also limited by these same constraints. As they arrive on campus, they can be easily overwhelmed by the exorbitant cost of their required textbooks and the plethora of activities in which they are required to participate or to which they are invited. Clubs, diagnostic exams, placement exams, advising, scheduling. Given such constraints, it would seem easier just to follow the paths established in previous years.

## Dissatisfaction with introductory labs abounds.



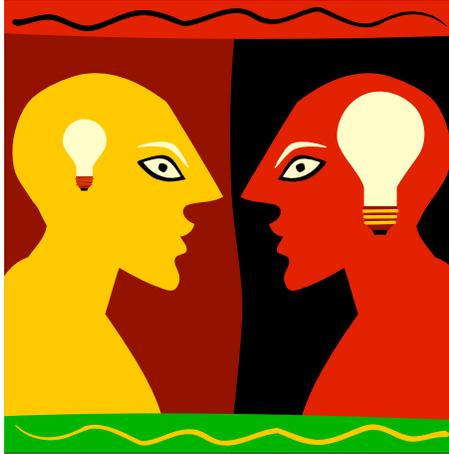
But our previous experiences also gnaw at us. Introductory laboratories are particularly challenging. We find that even our best students don't come to college having had a positive, engaging, enriching laboratory experience in high school. Although they may place out of the introductory lecture sequence, they are almost always best served by participating in the introductory laboratories anyway. As we construct a curriculum for these labs, we as faculty members face a difficult dilemma: should labs reinforce lecture material or should they be developing complementary skills? I have found students frustrated by the format of laboratories - not enough time to complete the activities prescribed, more work than a 1-credit class should require, not enough instruction on preparing reports, etc. From the instructors point of view, comments we write on student papers seem too often ignored. We wonder if the time we invest in grading has been worthwhile. And the stacks of papers with which we're confronted can be overwhelming.



Intro labs are proving grounds for creativity and learning.

Yet despite their shortcomings, these introductory lab experiences have rich potential for students -- if we as their instructors can create a flexible, thought provoking, positive lab experience, and if we can think of these labs as teaching students about more than just the subject itself, whether physics or biology or architecture. Laboratories provide an environment in which students can effectively develop many of the skills recognized as essential in a liberal undergraduate education: reading, writing, speaking, reflecting, teamwork, problem solving, creativity, etc. AAC&U report highlights that our students are woefully unprepared in many of these areas. It seems worth our while to explore ways to make our labs the type of enriching experience that students will eagerly WANT to take. And we will suggest that the “lab” format is the ideal format for delivering content that students will remember. The challenge may be how to revise all of our classes to take on more lab-like characteristics to further liberal undergraduate education.

## Innovations stimulate learning in multiple dimensions.



So this panel discussion will explore the creative ways faculty members at several institutions have approached the problem of conducting introductory laboratories in a way that engages students in the frequently overlooked or at least less emphasized liberal education goals. We have examples today from physics, biology, architecture, and education. I look forward to the presentations of my colleagues and the comments that you have to share with us. Recognize that our programs are works in progress -- each with strengths and weaknesses, each requiring further development and exploration. But feel free to adapt, steal, tweak, criticize, or respond to anything you hear today. We welcome your feedback!

# 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



## Important to understand class



### Demographics

Who are your students?

Class, majors, backgrounds

### Knowledge

What have they learned (or not)?

Assessment instruments, correlations

### Attitudes

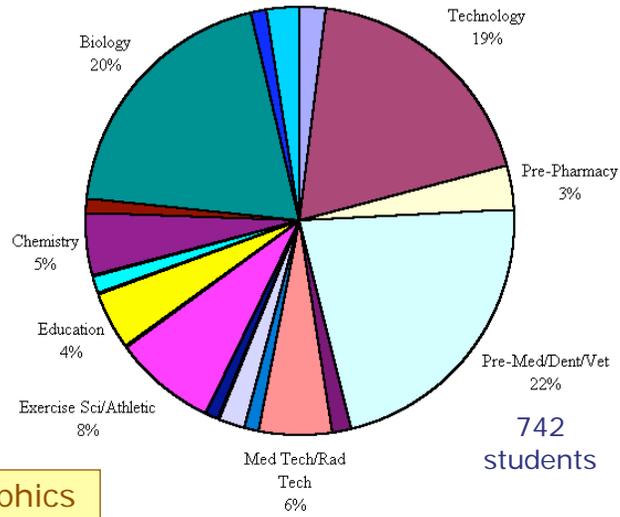
What do the students think?

Surveys, evaluations, feedback

Can  
Adapt to  
Students' Needs

## Student Majors in Algebra-Based Intro Physics

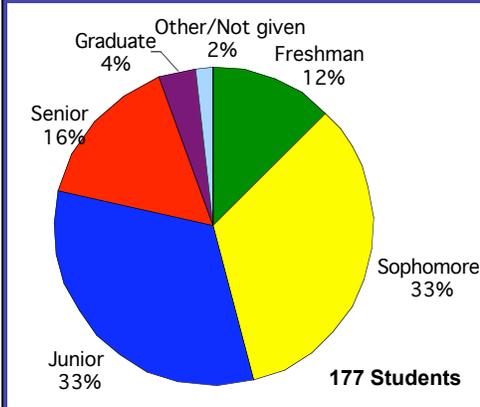
(2003 – 2005) Algebra Based Physics 1<sup>st</sup> semester



Demographics

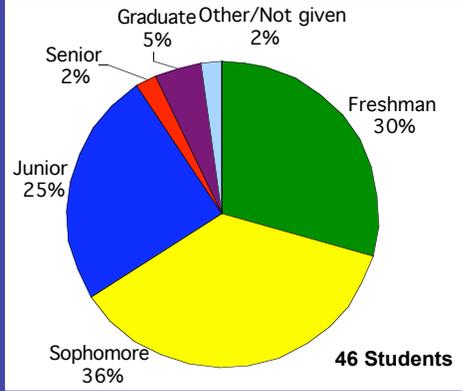
# Introductory Physics Student Class

Fall  
2003  
Data



Calculus-Based  
(1st Semester)

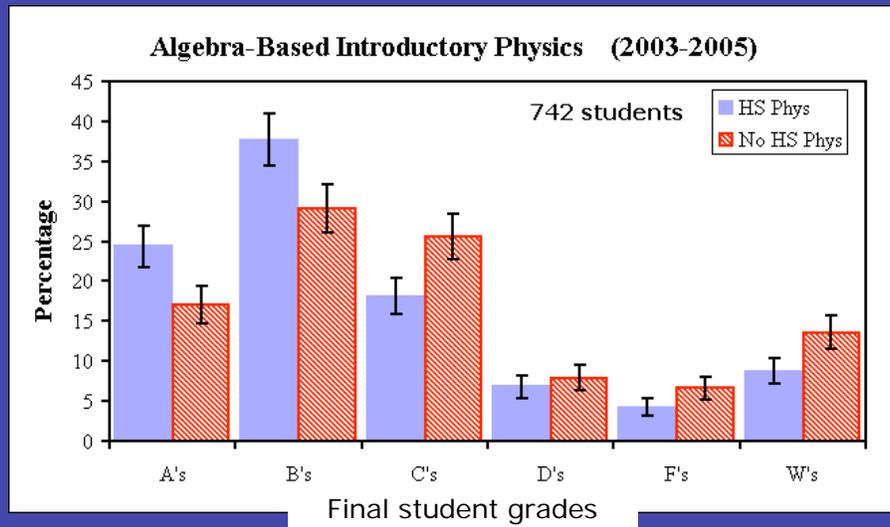
Mostly frosh and  
sophomores



Algebra-Based  
(1st Semester)

Mostly juniors and  
sophomores

## Correlation with High School Physics



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

Knowledge



## FCI Question Analysis



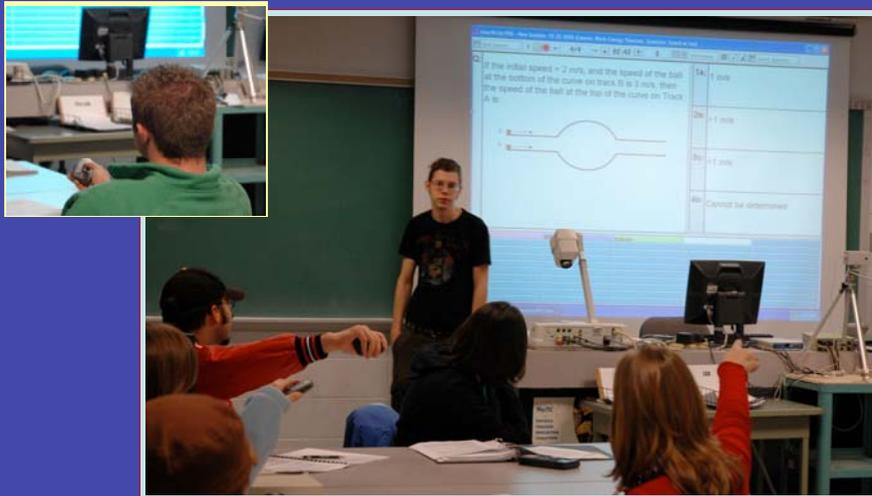
Example: A large truck collides head-on with a small compact car. During the collision:

Answers (paraphrased)	<u>Pretest</u>	<u>Posttest</u>
A. Truck exerts greater force on car	74.7%	37.4%
B. Car exerts greater force on truck	1.1	2.6
C. Neither exerts force on other	0.5	0.7
D. Truck exerts force on car, not vice versa	1.3	0.9
E. Truck and car exert same force	22.4	58.4
	N = 621	N = 543

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

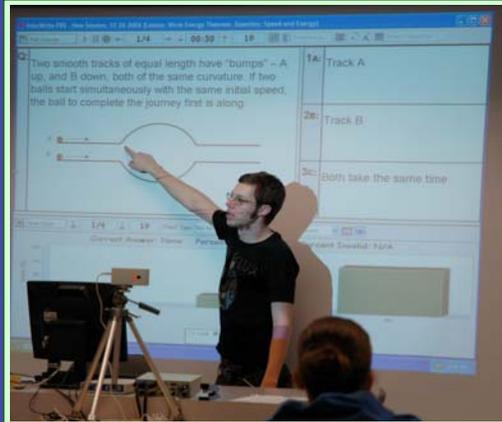
Similar questions in lab to improve conceptual learning

## Use of Personal Response System in Lab



- More practice with conceptual questions
- Introduction to lab ideas

## Personal Response System Method



**Results:** Under scrutiny

**Benefit:** Get students “prepped” and thinking about lab

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

## 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



# Christopher Hight – Architectural Laboratories

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*



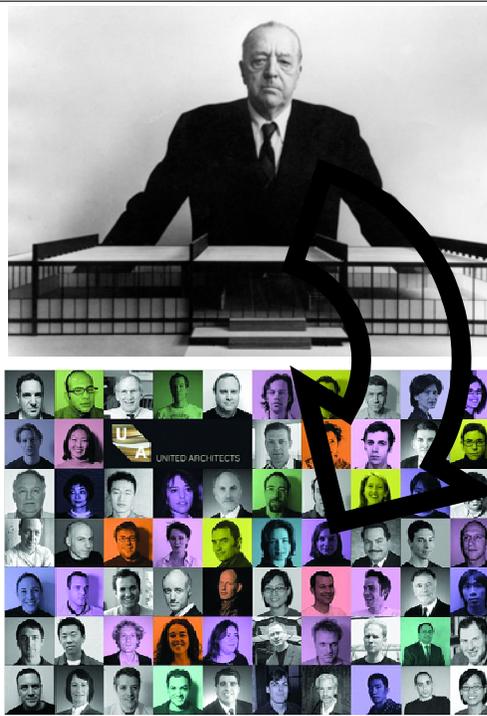
## The image of creative activity



- The image of the heroic genius
- Creative acts as the opposite of science and methodical research.
- The cliché that architecture is a synthesis of art and science.

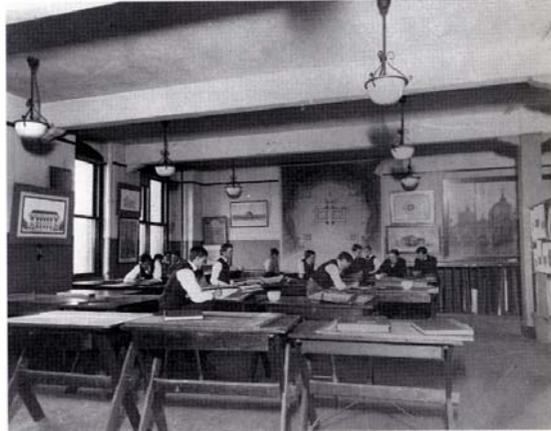
**Liberal Education,  
Professional Training  
or Academic  
Research?  
Architectural Education  
as Model**

- 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.



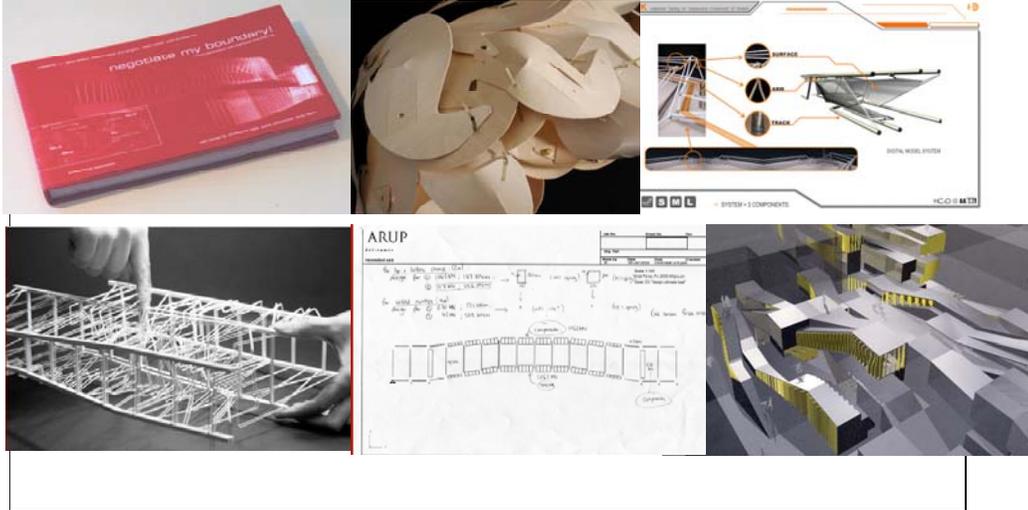
# Architectural Laboratory is:

- **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

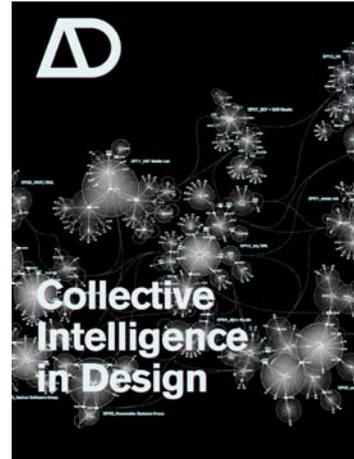
individualized tutorials, group presentations, student

professor sets frameworks, guides processes



# Architectural practices of research through design

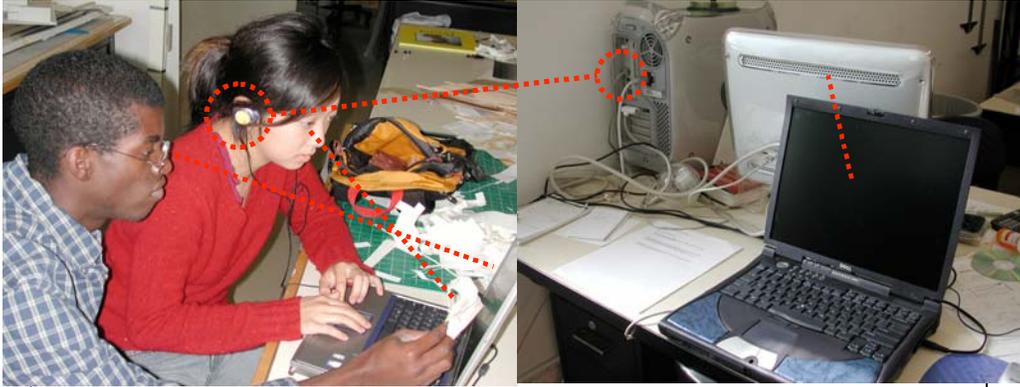
- Architectural Labs do not teach “architecture” as a body of knowledge so much as inculcate the student into the culture of architecture.
- Through the studio one learns how to be an architect.
  - this is an ethical model of education
  - the goal is not learning a rule set, or a method, though these can be instrumental



# 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.



Establishing critical and independent thought by understanding the structures through which one innovates thought and practice.



**Laura Blasi**  
**Assessment & Institutional Research**



[Click Here](#)



# Context: NASA's Virtual Lab Software

http://virtual.itg.uiuc.edu/software/



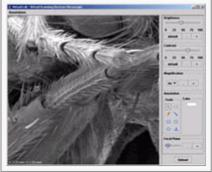
Imaging Technology Group  
Virtual Projects

home software data training results downloads

## Software

### The Virtual Microscope

The Virtual Microscope is a Java application that supports interactive viewing of high-resolution, multi-dimensional image datasets from various microscopes. We currently support data from a [Philips Environmental Scanning Electron Microscope \(ESEM\)](#), and a [Fluorescence Light Microscope](#).



[Download the Virtual Microscope interface](#) →

#### Latest News

- [Atomic Force Microscope Training Animation Released](#)
- [Light Microscope Training Animation Released](#)
- [Scanning Probe Samples Posted](#)
- [Version 6.0 Released!](#)
- [New Microscopy Careers Movies posted](#)
- [Updated Help Movies Posted](#)
- [New Sample Preparation Movies posted for LM](#)

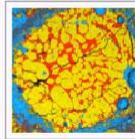
# A Snapshot

- The role and range of types: Virtual Labs
- The controversy for our freshman classes – specific to high school STEM.
- Some of the evidence regarding effectiveness.
- The questions raised regarding the role of virtual labs in liberal arts colleges & universities.

## Meteorite (EDS) [Recent]

Built from raw data totalling 478.4MB (167.2 megapixels)

Meteorites are pieces of rock that fall to Earth from space. This meteorite came from an asteroid. It is made of dust that formed 4.6 billion years ago, when the planets were just beginning to form. At that time, the Solar System was a cloud of dust and gas that circled in a disk around the newly-formed Sun.



## Virtual Labs in the context of educating students in the liberal arts...

- When considering ways of stimulating student learning in multiple dimensions through introductory laboratories...
- They allow all students access at a highly sophisticated level, rapidly able to tackle topics and tools inaccessible through texts and talks...
- ...even at schools that have tightened budgets and limited equipment.

## **Virtual labs in high school and college education provide access.**

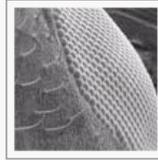
- With much discussion of the need for “hands-on” learning in the sciences, virtual labs allow students access that may have been out of reach due to limited budgets but also the lack of space.

# As students to look at everyday in a new light...

## House Fly (2)

Built from 10,080 images totalling 6.8GB (2.4 gigapixels)

The common house fly is a stunning sight up close, revealing a veritable world of structure that is unseen by human eye. This tiling of a complete house fly (underside) shows the legs, abdomen, head, and mouth parts clearly.



# Share new discoveries quickly

## Xyloplax (Ventral View)

Built from 1,596 images totalling 1.1GB (385.1 megapixels)

*Xyloplax* is a monotypic genus within the Concentricycloidea, an infraclass within the Asterozoa. Details of this new species are to be published in the May 2006 issue of

Invertebrate Biology by Chris Mah, a scientist specialized in deep-sea starfishes. The ventral

(bottom) view shows the tube feet that may be found around the edges of the disc-shaped animal. The patchwork pattern in the middle is due to charging--an undesirable phenomenon that was unavoidable with this particular sample.

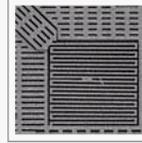


# Prepare for a new generation of innovation...

## Accelerometer (SEM)

Built from raw data totalling 94MB (32.8 megapixels)

Accelerometers are used to detect changes in velocity. They are attached to various devices, such as cars, planes, and spacecraft in order to provide information vital for navigation and safety systems. One example use is in your car, where the accelerometer helps the car's computer know if you have gotten into an accident-triggering the release of the air bag.



## Virtual Labs: Before Computers

There are different definitions of virtual labs, with new technologies replacing prior solutions such as video tapes and home kits.

- (Earlier perspectives: Alhalabi, B., Hamza, M.K., et al. (1998). Virtual labs vs. remote labs: Between myth and reality. *Florida Paper presented at the Higher Education Consortium Statewide Conference*. 7th, Deerfield Beach, FL, Nov. 12-14.)

## Seeking to clarify the recent innovations

- The increase of online learning is one of the innovations that has pushed Virtual Labs to the forefront.
- At a recent annual meeting of virtual schools, debate over the use, authenticity, and impact of virtual labs was complicated when multiple definitions were unspoken.

## The Range of Virtual Labs

- Interactive spaces and scenarios
- Remote access to equipment (SEM)
- Simulations of scientific tools and concepts

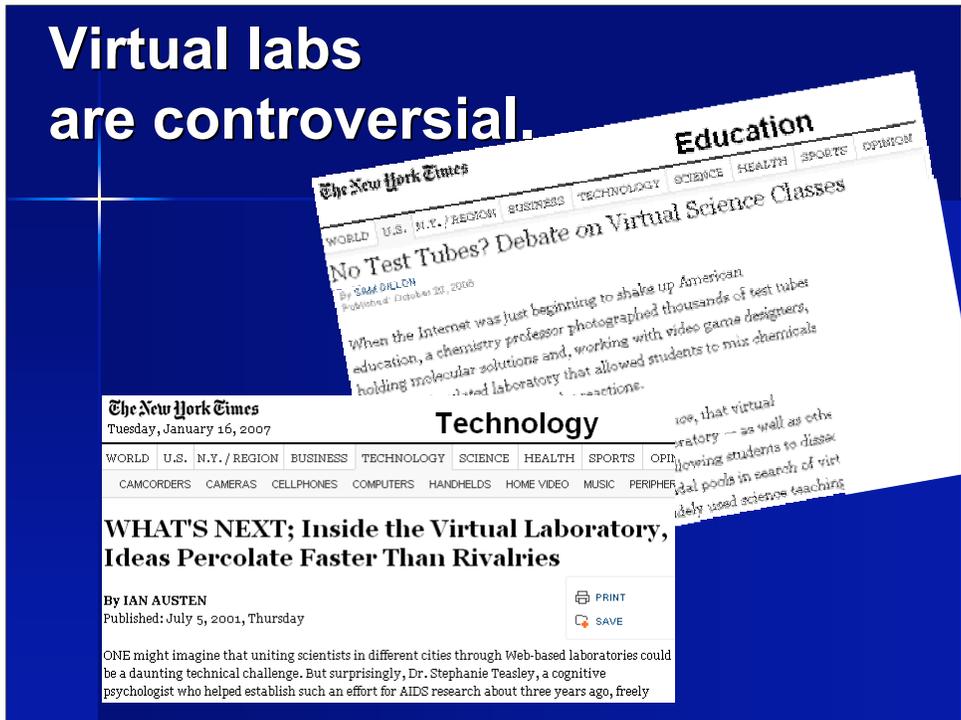
## The range Virtual Labs and the use of unspoken definitions...

...becomes an issue when we talk about preparing the next generation of scientists alongside the larger student population who are to become scientifically literate.

- How do we assess?
- How do we certify?

Consider: What is lost balanced with what is gained.

# Virtual labs are controversial.



## Caution: Why and what it means

- Authentic experience, not standardized, “kitchen science” ...
- The College Board is questioning preparation for AP exams. (No AP designation without physical labs).

## **Results: In the context of priorities in US public education**

- 113 Internet-based schools; the Florida Virtual School (approximately 40,000 students, the largest in the US) demonstrated impact on student learning (higher average AP scores).

## What Virtual Labs Offer Students of the Liberal Arts

- Virtual labs allow us to do things previously out of reach that have an impact on learning.
- Allows more diverse populations access across socio-economic status (SES) levels.
- New experiences in the majors and the core curriculum... scientific literacy developed in terms of experiences, as well as language.

## Research Shows Effectiveness

- Specifically score impact improves;
- Students learn skills (hands-on), and also
- Prior research describes how to improve impact.

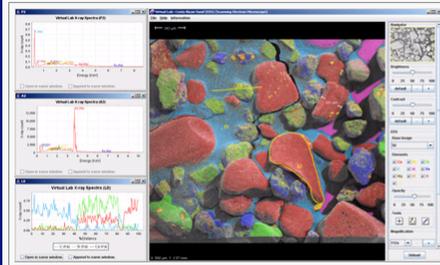
- Lee, J. (1999). Effectiveness of computer-based instructional simulation: A meta-analysis. *International Journal of Instructional Media*, 26(1), 71–85.
- Vogel, J., Vogel, D., Cannon-Bowers, J., Bowers, C.A., Muse, K., and Wright, M. J. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research*, 34(3), 229-243.

Virtual Labs at schools that want students to learn across multiple dimensions through introductory laboratories.

- Which dimensions are included in the objectives?
- Which types of virtual labs will you use?
- Will your faculty be appropriately trained?
- Is impact measured by scores...  
...or is there more to learning?
- What is needed for a well-rounded lab experience?
- So... What are the objectives and the measurable outcomes for the study of science through virtual labs in the context of the liberal arts.

# To access and try out an example: NASA's Virtual Lab (a simulation of a scientific tool)

## The Virtual Microscope



The Virtual Microscope is a [NASA-funded project](#) that provides simulated scientific instrumentation for students and researchers worldwide as part of NASA's Virtual Laboratory initiative.

### Latest News

- [Atomic Force Microscope Training Animation Released](#)
- [Light Microscope Training Animation Released](#)
- [Scanning Probe Samples Posted](#)
- [Version 6.0 Released!](#)
- [New Microscopy Careers Movies posted](#)
- [Updated Help Movies Posted](#)
- [New Sample Preparation Movies posted for LM and AFM](#)

### Latest Specimens

- [SPM: Integrated Circuit](#)

<http://virtual.itg.uiuc.edu/software/>

# Rob Swanson

Peer instruction and evaluation in  
biology lab



VALPARAISO  
UNIVERSITY

## 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



Problem: In Botany class, students often see learning about different plant taxa as tedious, boring and with very little relevance to daily lives

Rather than try to convince them that plant taxa are not boring, and have a great deal of relevance, I decided to shift the burden of proof to the student.

In making that decision, I decided that they don't need to convince me that plant diversity is fascinating, and that plants have tremendous impact on humans. They need to convince each other. So, I wanted to change the evaluation parameters (formal and informal) to focus on how students react to presentations, rather than me.

## Establish learning goals for the exercise

- Physiology/Morphology
- Role in ecosystem
- Role in human affairs
  
- Audio presentation



For my exercise, the learning goal was to describe the physiology and morphology of a plant family, do library research to find what is known about the role the family plays in the ecosystem and in human affairs.

Students picked a random plant family from hat. They put together a 6-8 minute audio presentation on the family, and it was digitally recorded. CDs (and MP3 files) were put together so the presentations could be listened to by the class at the Field Museum, in the botanical exhibit (where there are showcases of all the possible families the students could have chosen)

## Using peer pressure and legacy to increase quality of scholarship



Legacy component:

Recordings passed from one year to the next.

Past presentations are included for future classes, with name and year of the presenter. No impact on grade, but this more than anything has impacted student anxiety/performance.

# Flexible Evaluation

- Quiz
- Reflection on impact on human society



The evaluation was basically a quiz the students take that covers the information that should be in the presentation, as well as a reflection on the societal impact of each family. It was due the following week. The students were very clear in their take homes when presentations did not deliver the required information. They also enjoyed reflecting on the more interesting botanic-human connections

Of course, the field trip included additional exercises that incorporated other museum resources... this was just one (major) goal of the trip.

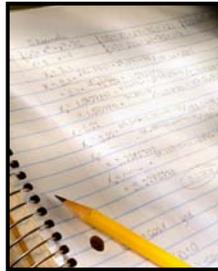
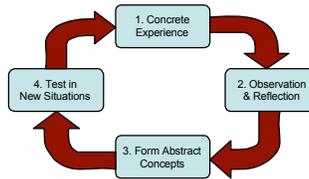
## Faculty observe enhanced quality and engagement



Evaluations and the way the project is presented is changing over time, but audio presentations at museum success

Doesn't necessarily need museum... botanical garden would be ideal as well

# Physics lab promotes multiple dimensions of learning.

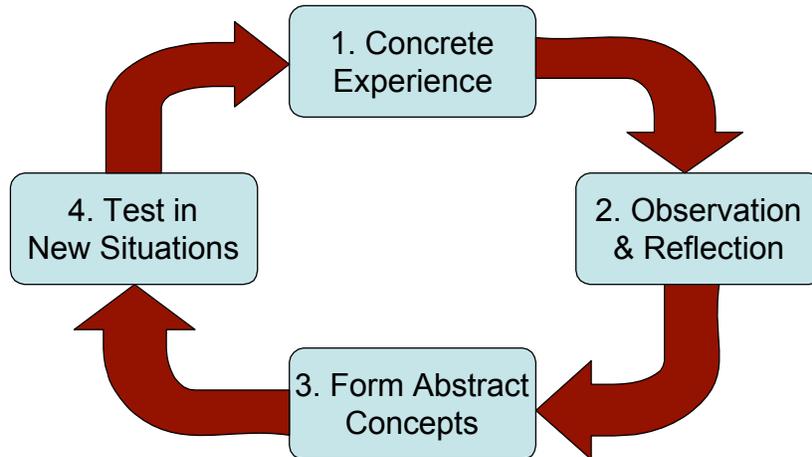


VALPARAISO  
UNIVERSITY

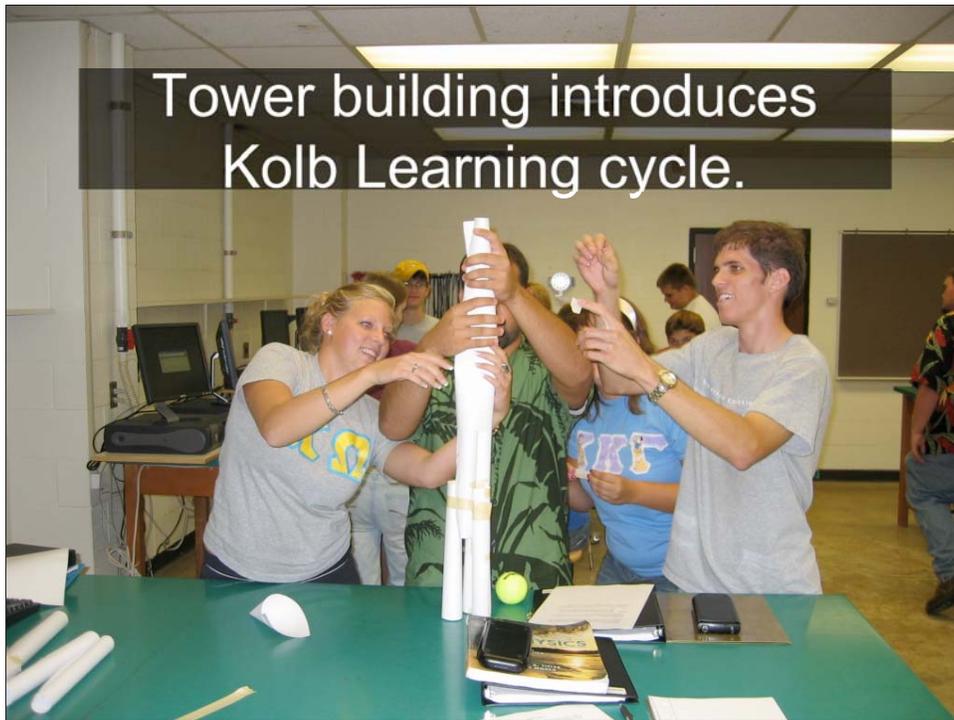
Gary.Morris@  
valpo.edu

During the Fall of 2006, we began a process of realigning the goals of our introductory physics laboratory sequence at Valparaiso University. In the past, we covered a new lab during each week's 2.5 hour session. The lab emphasized breath of coverage. But it also required weekly reports from the students on their procedure, analysis, and calculations. Error analysis was expected from early in the semester. Students were also expected to write abstracts from their lab experiences at a very early stage. The amount of work was overwhelming for both students and instructors. With so little time and so much to do, it seemed students were mastering very little of the content. We wrote the same comments week after week on the reports we returned. And by the end of the semester, it was difficult to keep up with the influx of papers from our students. Today, I'll provide you with an overview of our innovations, highlighting the extent to which they promote teamwork and the achievement of the goals of a liberal undergraduate education by building upon the Kolb Learning cycle. I'll also share some initial feedback from faculty, students, and teaching assistants.

## Following the Kolb learning cycle promotes liberal learning.



The Kolb learning cycle provides students with an interactive approach to learning with sticky content. The first step in the cycle involves a concrete experience. These are easy to achieve in a lab environment, as students manipulate equipment and make observations of the various phenomena for which the experiments are designed. After the concrete experiences, students form a large circle to talk specifically about what they did in the process of constructing their towers. Next, the discussion is led to the abstraction of the from the specific content of the lab to the rest of their laboratory experiences, their other classes, their roommates, and life in general. The final stage, testing in new situations, would play out through the rest of the semester as we repeatedly recalled the lessons learned in previous sessions.



## Tower building introduces Kolb Learning cycle.

We began the semester with a “fun” exercise that was designed to create a positive atmosphere of innovation and teamwork in the laboratory while introducing the Kolb Learning Cycle model. Some of you may have seen the activity depicted here: build a tower as tall as possible that supports a tennis ball above the table top. You have 20 minutes, 12 pieces of paper, and 5 feet of masking tape. You can use nothing else. Teams of 4 were formed. The tower would be measured at the end and tested for stability using an earthquake test and a wind test. It was fascinating to watch our students engage in this activity.

## Non-threatening intro activity promotes collaborative culture

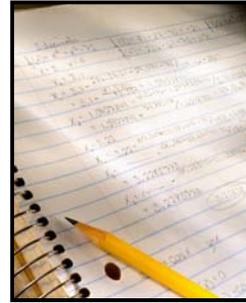


A wide variety of structures were created, some more successful than others. But the lab was buzzing with life and activity -- freshmen engaged, discussing, debating, building their structures. They came up with some pretty creative designs. Some were very tall but not stable; some were very stable but not very tall. Some were neither tall nor stable. But in each case, students presented their structures to their peers and stood by them as they were tested. And I should note that the students, on the whole, built much taller towers than the faculty members on whom I've run the same exercise.



The discussion time takes twice as long as the experience itself -- and it is during the discussion that students have the chance to learn, not only about the lab content itself but also about their strengths and weaknesses in the lab environment and more general principles in life. Starting with the specific: How did their group work? Did someone take the lead? Did you try testing your towers? Each group and each group member contributed to the discussion. Next: How do the skills you learned during the tower building apply to other labs this semester? Did you learn something about yourself? How might these skills apply to other classes? How might they apply to life in general. I want to share two comments from students who participated in this exercise. The first came from a student who was a member of a group that built a very short tower. They called it "the tower of shame." The most ethnically diverse group in the lab, they were quiet at first, working mostly independently. In the end, their design was a merger of the work of three independent participants. But one of the group members in presenting his tower still managed to comment that although their tower wasn't very tall or impervious to the wind, his teammate had created a structure that was very stable against the earthquake test. We then took this specific comment and generalized: Even if you are unable to meet all the objectives of the lab, you can take some pride in accomplishing some of them very well. The second comment was from a student who realized she was too timid in her group -- she needed to be more assertive. In generalizing, she said she was going to her RA to report the boys upstairs who were too loud at night!

## Lab learning objectives fulfill liberal education goals.



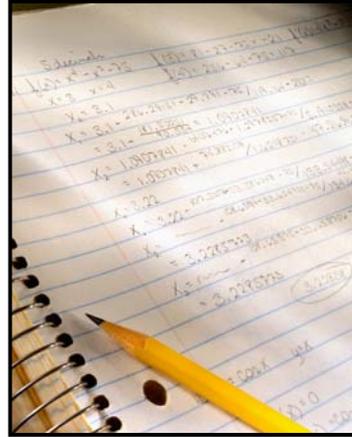
Each week, students were asked to complete a Pre-Lab assignment, forcing them to review the relevant physics associated with each laboratory. These written assignments were due at the beginning of each lab period. After a very brief introduction to the lab exercise, students began working on the task at hand. Innovation and experimentation were encouraged, where possible. Less prescriptive lab write-ups were developed to foster this sense of exploration, building on the tower building exercise. During the lab, students were expected to keep notes on their experience, recording data and procedures, calculating errors and commenting on uncertainties. The last 20 minutes of each lab period were reserved for discussion. Three times during the semester, students were asked to submit a typewritten reports. Thus, our lab incorporated many of the goals of liberal education.



Students gathered in a circle at the end of each period, just as they did for the tower exercise, to talk about specifically their approaches to the lab, problems they had, solutions they found, procedural suggestions, etc. Where possible, references to previous experiences were exploited, tying the material together from week-to-week, creating a common thread and theme for the lab. These discussion times allowed us as instructors to emphasize some of the more subtle points of the labs, focus on the nature and sources of errors, and share ideas and solutions to improve the labs for next year. We challenged students to think outside the lab manual about how things might be done differently or better next time. This semester, we're revising our lab further so that each lab exercise covers 2 weeks of time. With the discussion time in the middle, students will then have a chance to implement the following week some of the ideas surfacing in the discussion time.

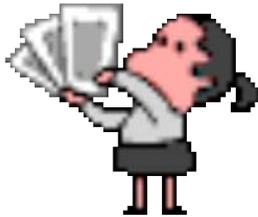
## Written reports require synthesis and self-evaluation

- I need to be more assertive.
- I want to learn Excel.
- After this lab exercise, I finally understood error analysis.



We divided our lab exercises into three groups: one focused on gravity, a second on Newton's Laws, and a third on Conservation Laws. At the end of each of these three groups, students were asked to submit a typewritten reports exploring commonalities in the lab exercises, summarizing their observations, and reflecting on their own strengths and weaknesses. They were to include data and graphs from the lab exercises to support their arguments. Although we didn't know quite what to expect when we initiated these reports, we found that the students were remarkably candid in their self-evaluation. They were less sure, however, about how to form logical arguments, and some students clearly had deficiencies in their writing skills. We encouraged them to seek assistance at the university's writing center. In the past, we wouldn't have been in a position to make such recommendations to help students develop their writing skills. In that way, the reports promote broader educational goals and life skills for our students. The self reflection and evaluation allowed students to define their own educational objectives: "I want to be more assertive in my group;" "I want to learn Excel;" "I finally understood how to do the error analysis properly."

## Reshuffling lab partners maintains collaborative culture



In my section, I randomly scrambled lab partners at the beginning of each of the three groups of lab exercises. We have noted in the past that lab partners tend to pair up with individuals at about the same level of competence and ability. Is that fair? Are students better served by working with individuals with different strengths and weaknesses? “We teach best what we most need to learn,” and “We never learn something as well as when we have to teach it to someone else,” are two adages I try to live by. Shuffling lab partners gives students a chance to work on their teaching skills, emphasizing peer instruction, and prevents someone from cruising through the whole semester in a comfortable, well-defined role. Students noted that changing partners kept them from always falling into the same role each week -- for example, the “Excel” guru.



Faculty reflect on the strengths and weaknesses.

My colleagues kept logs of their experiences in the lab, as redesigned, and reflected on how things differed from past lab incarnations.

“ I had to consciously remind myself that the goal of the exercise was NOT to help the students get the best agreement with the expected value, but rather to help them learn some important lessons about experimental technique and analysis.”

“Several students have told me that they like this because it helps them better understand the purpose of the experiment and the meaning of their results.”

“Once again, we had time for discussion at the end of the lab, and that seemed to help students “process” their results and compare them to those of other lab groups. I am more and more convinced that it is a good thing to compile class results and show them to the students.”

“Since they are all keeping a more detailed record of their lab activities than students have done in the past, and since they are expected to turn in their reports at the end of the lab period, they are moving through the tasks more slowly and deliberately, stopping to write down details and make observations. So following the classic law of unintended consequences, my students are probably documenting their work much more carefully but getting far less of it done in the time allotted! “



One of my student TA's noted a much higher degree of collaboration and cooperation in the lab with the new format. Students interacted with each other, consulting with other groups about how to perform measurements or get a piece of equipment to behave, than they had in the past. Reliance on themselves and their peers was enhanced.

# Multi-week exercises enhance student innovation & learning.

Tentative Menu of Laboratory Exercises	Date (Week of)
No Lab (first week of class)	Aug. 21
<b>Unit 1: Gravity – Report Due week of 10/2</b>	
1.1. Introduction to Laboratory	Aug. 28
1.2. Measuring the Acceleration of Earth's Gravity	Sept. 4
1.3. Earth's Gravity Revisited	Sept. 11
1.4. One-Dimensional Motion	Sept. 18
1.5. Projectile (Two-Dimensional) Motion	Sept. 25
<b>Unit 2: Newton's Laws – Report Due week of 10/23</b>	
2.1. Free-Body Diagram Workshop	Oct. 2
2.2. Force and Acceleration	Oct. 9
2.3. Uniform Circular Motion	Oct. 16
<b>Unit 3: Conservation Laws – Report Due week of 12/4</b>	
3.1. Work – Energy Theorem	Oct. 23
3.2. Work Done and Change in Kinetic Energy	Oct. 30
Work Done and Change in Kinetic Energy (Con't)	Nov. 6
No Lab (Special Physics Lecture)	Nov. 13
No Lab (Thanksgiving Break)	Nov. 20
3.3. Collisions and Conservation Laws	Nov. 27
4. Make-up Lab (TBD)	Dec. 4

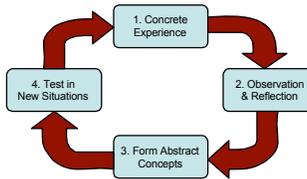
Twice during the semester, labs extended over two weeks. These labs allowed students to be more creative and implement suggestions from the discussion time at the end of the first week. Although this past fall we had a new lab exercise nearly every week, we are now moving toward doing fewer labs, but expecting more from our students on each lab. We want to encourage thinking outside of the lab write-up and the book. If the students are wondering about the impact of “air resistance” on their measurements, they should be encouraged to explore that effect and share their observations with their peers. That is the process of science - and that’s a primary educational objective of our introductory laboratory experience. Students should be encouraged to THINK about what they’re doing, how to ask questions, and how to answer those questions for themselves through experimental design! So, starting this spring, we’re moving to two-week labs for each exercise we assign.

less

IS MORE!

We also have introduced error analysis, graphing, conclusion writing, and abstract writing more slowly - not expecting students to do everything from the beginning of the semester. We have “workshops” on error analysis and free-body diagrams focused just on developing those skills. These workshops take the place of the regularly schedule lab exercise, but allow the students to focus and master one skill at a time. Also, by having fewer exercises each semester, students will get more out of each one. We’ll not be rushing through them just to finish -- there’ll be plenty of time to think and explore and finish the error analyses. As with many aspects of life, “Less is more.” As one student commented on his/her final course evaluation: “I wish the lab manual had less information in it so that we would be forced to think more creatively on our own.” I took that comment as a mark of the success of our approach.

# Physics lab promotes multiple dimensions of learning.

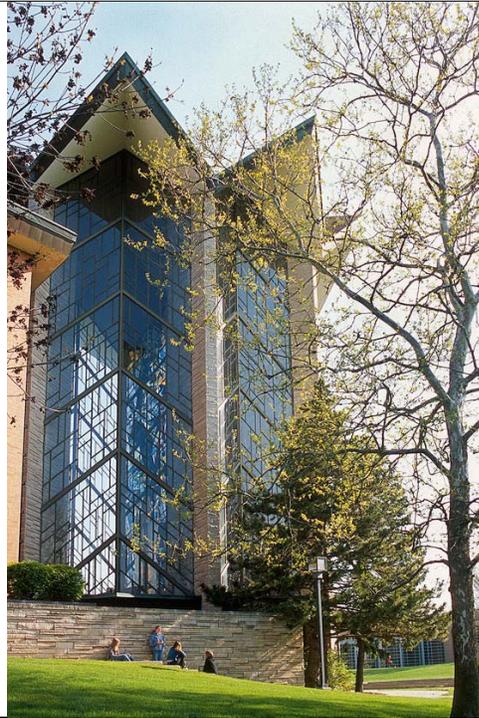


VALPARAISO  
UNIVERSITY

Gary.Morris@  
valpo.edu

In this part of the presentation, I've introduced you to the innovations we implemented in the intro physics lab at Valparaiso University. Using the Kolb Learning cycle, we achieved many goals of a liberal undergraduate education through our revised lab exercises. Students worked effectively in teams, had the opportunity each week to communicate their ideas verbally to their peers and think creatively and critically through group discussion, and submit written reports three times during the semester. Faculty and student evaluation was not uniformly positive, but overall, we feel our experiment is worth tweaking and repeating. I'm happy to talk with any of you about our experiences at Valparaiso Univ.

Can  
innovative  
labs inspire  
and  
promote  
liberal  
learning?



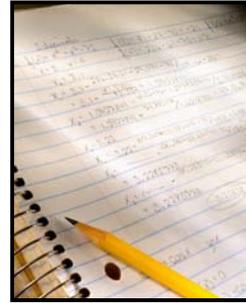
We've seen four different approaches and innovations in a range of disciplines for introductory laboratory activities, all of which promote and advance the objectives of liberal education.

Traditional  
labs often  
frustrate  
both  
students  
and faculty.



The more traditional laboratory formats often leave faculty and students frustrated and/or disappointed. Often, laboratories lack clear educational objectives, but despite this much is still demanded of both faculty and students.

## Liberal learning objectives improve lab efficacy.



By incorporating some of the broader liberal education objectives, the laboratory activity itself is enhanced. Lessons learned in the lab can be applied in non-science courses and to life beyond. Students develop skills that they can take beyond the course.



We hope today's session has provided you with some ideas for developing new laboratories and that you might think of laboratory activities as an integral part of a liberal, undergraduate education. As we've seen, labs are not just for science or scientists. The thinking and problem solving skills promoted in a creative lab environment will be useful to our students for their entire lives.



Labs can enrich student & faculty experiences.

And perhaps, the laboratory environment can be adapted to non-science classes, offering a new, exciting vehicle for delivery and mastering of liberal learning objectives.

Think about this: What would an undergraduate education look like if every class was a lab class?

## **Stimulating student learning in multiple dimensions through introductory laboratories**

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

Panelists:

- Dave Grosnick (dgrosnick@bsu.edu)
- Christopher Hight (chight@rice.edu)
- Laura Blasi (Laura.Biasi@saintleo.edu)
- Robert Swanson (Rob.Swanson@valpo.edu)
- Gary Morris (Gary.Morris@valpo.edu)

Thanks for your attention. Here's our contact info. Let's now take a few questions.