Student-Centered Activities for Large Enrollment University Physics

Robert J. Beichner

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NC STATE UNIVERSITY
Physics Education R & D Group
What is SCALE-UP?

- **History**
  - IMPEC Project (SUCCEED Coalition)
    - Move integration to engineering course
    - “Scale up” the number of students in physics component

- **Philosophy**
  - Active learning via new/adapted materials
  - Employers want team and communication skills, problem solving, critical thinking, etc.
  - Technology allows instructors to move around room
  - Minimal additional cost (staff and equipment)
Approach

• Lecturing minimized and focused
  – Supplement text
  – Organize
  – Motivate

• Labs folded into the same class time
  – Regular Labs (with formal reports)
    • Skill acquisition, writing, scientific approach
  – Ponderables & Tangibles
Ponderables

- How many two-step paces is it from LA to NYC?
- What are the dimensions of the standard kilogram?
- How far does a bowling ball get before it stops skidding and is only rolling?
Tangibles

• What is the thickness of a single page from your text?

• Find the coefficient of kinetic friction between your book and the table.

• Find the number of excess charges on a piece of tape pulled off the table.
Modification of Existing Curricula

• Already very well designed, research-based
• Adapt for fewer instructors, more students
• Washington Tutorials
  – Less paper-based, more “tangible”
  – Break into short segments with discussion
• Minnesota Group Problem Solving
  – “Real world” problems
  – Presentations replacing quiz
  – GOAL Protocol
Phase I Classroom 70 students
Phase II Classroom

Before (55 students)

After (54 students)
Phase II Classroom 54 students
Phase III
Classroom
99 students
Phase IV Classroom ?
Classroom Layout

• Round Tables 6’ Diameter on 10’ Centers
  – Each table: 3 teams (each with laptop) of 3 students
  – Too small, too close: new close-packing law

• White Boards Surround the Room
  – Need one board per table

• Two Ceiling-Mounted Projectors
  – Will try screen sharing
  – Instructor station & Elmo Visual Presenter

• Need Student Access to Equipment
Benefits of Equipment Access
Classroom Management

• Utilize table & group organization: A1 → F3
  – Equipment in plastic bags or containers
  – Paper collection & distribution from tables
  – Roll die to collect notes, homework, pick presenters

• Nametags for the first few weeks
  – No one can be anonymous
  – Friendly, risk-free atmosphere

• Materials available on the web
  – Syllabus, calendar, daily activities
Grading

• Every minute per student paper = 1.5 hours
• Group Assignments
• Rapid Grading Scheme: ✓– ✓ ✓+ 
• Random “sampling”
  – Notes
  – Homework problems
    • Utilizing GOAL Protocol
    • Preparation before class enforced via WebAssign
Cooperative Grouping

• **Individual accountability.** Each member is responsible for doing their own fair share of the work and for mastering all the material.

• **Positive interdependence.** Team members have to rely upon one another.

• **Face-to-face interaction.** Some or all of the group effort must be spent with members working together.

• **Appropriate use of interpersonal skills.** Members must receive instruction and then practice leadership, decision-making, communication, and conflict management.

• **Regular self-assessment of group functioning.** Groups need to evaluate how well their team is functioning, where they could improve, and what they should do differently in the future.
Does it work?

• Problem Solving
  – Fall 98, Outperformed peers 88% of the time.
  – Spring 99, Did better on 20 of 29 problems.

• Conceptual Learning
  – Fall 98 \( \langle g \rangle_{\text{FCI}} = 0.43 \)
  – Spring 99 \( \langle g \rangle_{\text{FCI}} = 0.52 \)
    \( \langle g \rangle_{\text{FMCE}} = 0.38 \) (3.5 \( \times \) gain of NCSU peers)

• Attitudes
  – Work harder than regular sections, but worth it.
  – Failure rate for females is \( \frac{1}{3} \) and for minorities \( \frac{1}{4} \) that of traditional sections
FCI Comparison

Four bars on the right are the same instructor.
Graph Interpretation & Problems

![Graph showing scores for TUG and Problems]

Scores

Interactive

Traditional

TUG - K

Problems
On the classroom design:

“I can deal with the lecture class, it is just that I enjoy more...getting more into the interactive projects. It is more hands on. If you don’t understand something you **just ask the guy next to you**, nobody yells at you for talking.”

“...you have your professor right in the middle and you have a couple of guys spread out and you can flag them down –‘Hey, can you answer this question for me?’ In the lecture, you are sitting 100 rows back, 25 rows back, **you really don't have anyone but the two people next to you and they don't know**. You really don't have anyone with some knowledge to help you out.”
On what is learned in SCALE-UP:

“I actually know how I learn through the SCALE-UP physics...through the way that it is set up, through the way they taught us by solving problems. It helped me to learn not so much to get an answer but to actually understand concepts. I also apply that to the rest of my classes. I think from now on, I will do a lot better in my classes just by taking this class—through all the teaching we learned how to solve problems and think through problems.”

“I have studied for a test with some of the traditional 205 students and like they always point to the book for everything, like looking for a formula for everything. Dr. Beichner makes sure that we understand the concept, we can almost derive the formula for whatever we need. And we seem to understand more of the aspects of physics. I definitely feel that, compared to traditional, we have a more in depth understanding and knowledge of what is going on.”
“Products”

- Lesson Plans
  - Objectives, Student Difficulties, Tasks & Reasons, Questions to Ask, “Gotchas”, Alternatives
- Handouts, Web Pages, Supporting Files
- Classroom Design Specifications
- Teacher Enhancement Guidelines
- Assistance to Adopters
- “Mainstreaming” in Textbooks
“Mainstreaming”

**QuickLab**

Determine the thickness of a page from this book. (Note that numbers that have no measurement errors—like the count of a number of pages—do not affect the significant figures in a calculation.) In terms of significant figures, why is it better to measure the thickness of as many pages as possible and then divide by the number of sheets?

**Quick Quiz 36.8**

Which glasses in Figure 36.38 correct nearsightedness and which correct farsightedness?

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**Besides what you might expect to learn about physics concepts, a very valuable skill you should hope to take away from your physics course is the ability to solve complicated problems.** The way physicists approach complex situations and break them down into manageable pieces is extremely useful. We have developed a memory aid to help you easily recall the steps required for successful problem solving. When working on problems, the secret is to keep your GOAL in mind!

**GOAL Problem-Solving Steps**

**Gather information**

The first thing to do when approaching a problem is to understand the situation. Carefully read the problem statement, looking for key phrases like “at rest” or “freely falls.” What information is given? Exactly what is the question asking? Don’t forget to gather information from your own experiences and common sense. What should a reasonable answer look like? You wouldn’t expect to calculate the speed of an automobile to be $5 \times 10^9$ m/s. Do you know what units to expect? Are there any limiting cases you can consider? What happens when an angle approaches 0$^\circ$ or 90$^\circ$ or when a mass becomes huge or goes to zero? Also make sure you carefully study any drawings that accompany the problem.

**Organize your approach**

Once you have a really good idea of what the problem is about, you need to think about what to do next. Have you seen this type of question before? Being able to classify a problem can make it much easier to lay out a plan to solve it. You should almost always make a quick drawing of the situation. Label important events with circled letters. Indicate any known values, perhaps in a table or directly on your sketch.

**Analyze the problem**

Because you have already categorized the problem, it should not be too difficult to select relevant equations that apply to this type of situation. Use algebra (and calculus, if necessary) to solve for the unknown variable in terms of what is given. Substitute in the appropriate numbers, calculate the result, and round it to the proper number of significant figures.

**Learn from your efforts**

This is the most important part. Examine your numerical answer. Does it meet your expectations from the first step? What about the algebraic form of the result—before you plugged in numbers? Does it make sense? (Try looking at the variables in it to see whether the answer would change in a physically meaningful way if they were drastically increased or decreased or even became zero.) Think about how this problem compares with others you have done. How was it similar? In what critical ways did it differ? Why was this problem assigned? You should have learned something by doing it. Can you figure out what?

When solving complex problems, you may need to identify a series of subproblems and apply the GOAL process to each. For very simple problems, you probably don’t need GOAL at all. But when you are looking at a problem and you don’t know what to do next, remember what the letters in GOAL stand for and use that as a guide.
Assistance

Our goal is to improve physics learning in large enrollment classes (or those with large student/faculty ratios), both at NCSU and nationally.

- Travel funds are available (supporting visits to NCSU and consultants from NCSU)

- Workshops for AAPT, materials on the web

More information at www.ncsu.edu/PER