

# Student-Centered Active Learning Environment with Upside-down Pedagogies North Carolina State University\*

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Skilled with the use of technology, able to use simulations to develop mathematical models, able to use software and hardware for data collection and analysis.
- Skilled in interpersonal communication, able to explain their reasoning in written and oral forms to peers and to evaluate oral arguments (their own and those of peers), able to demonstrate their knowledge and understanding of physics in writing, able to present a well-reasoned argument supported by observations and physical evidence, able to function well in a group and evaluate the functioning of their group.
- Socialized into the community of physics, aware that understanding physics means understanding the underlying concepts and principles; understanding physics as a coherent framework of ideas that can be used to understand many different physical situations; becoming part of a classroom community of learners.



## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Collaborating with peers on interesting tasks, opportunity for “hands-on” engagement with solving context-rich problems.
- Interacting with peers and with instructors, experiences reinforcing their ability to function well in a group.
- Interacting with equipment used by physicists to make measurements.
- Presenting and evaluating oral arguments; viewing and critiquing the work of individual teams.

\* and peer institutions





## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Room for instructors to circulate and work with students as teams and as individuals, engaging them in Socratic-like dialogue.
- Round tables 6' or 7' feet in diameter, each serving three groups of three students.
- Networked laptops for viewing work of individual teams at each table.
- White boards to be used as public “thinking” spaces all around the room; individual white boards for each team.
- Ubiquitous access to the web.

## HOW DO WE KNOW?

- Students’ ability to solve problems is improved.
- Their conceptual understanding is increased.
- Their attitudes are better.
- Failure rates (especially for women and minorities) are drastically reduced.
- “At risk” students do better in later courses.



# Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-UP)

*How do you keep a classroom of 100 or more undergraduates actively engaged as learners?*

*How do you enable students to practice communicating and working in teams in a large-enrollment class?*

*How do you boost the performance of students from groups currently under-represented in the study and practice of STEM fields?*

*How do you shape a learning environment that enables students to practice becoming a physicist, to begin to see what physics is, what physicists do?*

These are the kind of questions that catalyzed my reimagining of the introductory, large-enrollment physics class at NCSU in the mid 1990's. Initially called Student-Centered Activities for Large Enrollment University Physics, the title (but not the acronym) changed as the concept was adapted to other settings and disciplines.

The pedagogical approach is based on education research documenting how collaborative, immersive learning leads to improved academic outcomes for students. I started not with reimagining the space, but with articulating specific answers to a further question:

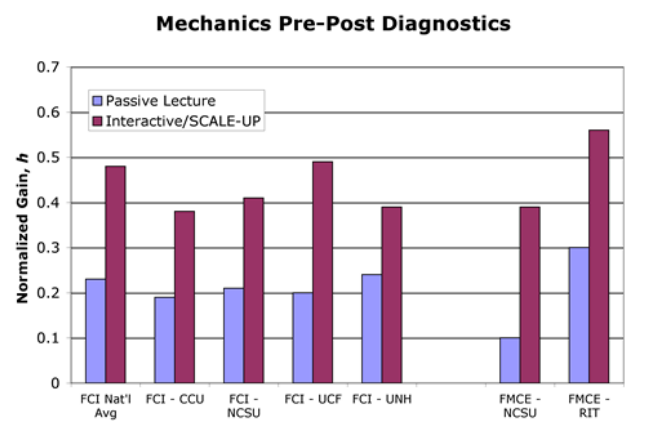
*What do I want my students to be able to do as a result of their engagement in my introductory physics course?*

From specific, detailed answers to that question I started with an iterative exercise: identifying assessment practices by which I could ascertain if students met my performance criteria, and then creating lessons and developing new kinds of instructional materials that reflected my desired learning outcomes and that could provide data for continuous assessment purposes.

Overall, a SCALE-UP environment is highly-interactive, collaborative, hands-on, and technology-rich. It works when there is co-development, implementation, and assessment of pedagogy, teaching, materials, and learning spaces. As far as I can tell, it works for all disciplines, within and beyond STEM fields. With the emergence of a national community of SCALE-UP adapters, significant evidence of efficacy has been documented.

## Assessment Evidence

Rigorous evaluations of learning have been conducted, either in parallel with curriculum development and classroom design work, or as a follow-up to such efforts. Many adopters have given conceptual learning assessments (using nationally-recognized instruments in a pretest/posttest protocol), and collected portfolios of student work. Several schools have conducted student interviews and collected information from focus groups, supplementing hundreds of hours of classroom video and audio recordings made at NCSU during the early development phases.



There is ample evidence from multiple adapting sites that students in SCALE-UP classes gain a better conceptual understanding than their peers in traditional lecture-based classes. As the figure indicates: for the first and second semesters of introductory physics, students performed better on a variety of conceptual surveys.

The pattern apparent in the figure below, where students in the top third of their class made the most progress toward perfect scores on the assessment tests, is an important counter-argument to those who complain that “reform courses only benefit the weaker students and we are ignoring the stars of tomorrow.” Clearly that is not the case.

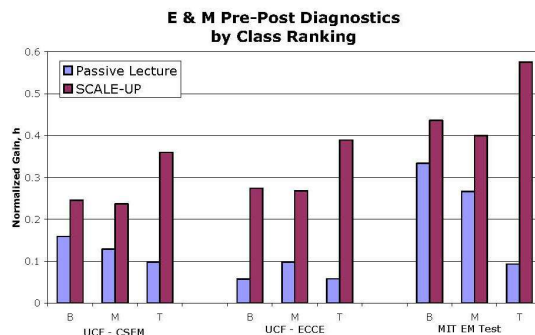
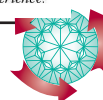


Fig. 6. Students in the top third of their classes gained the most from the SCALE-UP experience.



# Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-UP)

It is also important to note the affective outcomes of participation in a SCALE-UP learning environment. At institutions where they have the option, students almost always prefer SCALE-UP based classes compared to lecture courses. Although attitudes of SCALE-UP students are sometimes studied directly, they are more often revealed indirectly.

For example, students universally select the SCALE-UP version for their second semester course, they report their friends direct them into SCALE-UP classes (SCALE-UP sections fill before lecture sections). NCSU has a five-year average attendance rate of more than 90%, even though attendance is not required for SCALE-UP classes. At the very least, this implies that students value class time.

At best it may also indicate they enjoy learning in this type of setting—and it is clear the faculty enjoy teaching in such spaces. As noted in the evaluation of the pilot SCALE-UP classrooms at the University of Minnesota:

*The instructors who were interviewed enjoyed teaching in the rooms so much that their only concern was a fear of not being able to continue to teach in these new learning spaces. Similarly, more than 85 percent of students overwhelmingly recommended the Active Learning Classrooms for other classes.*

## A View into a SCALE-UP Setting

Peeking into one of these rooms, you would note that the learning space looks more like a restaurant than a classroom, or perhaps more like a banquet hall, because there is much noise from the visibly engaged students.

*“...you have a professor right in the middle and...a couple of guys spread out and you can flag them down...In the lecture, you are sitting...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.*  
— Student

Our challenge in redesigning the space for introductory physics was to achieve an environment that would promote the kind of active learning we wanted for our large enrollment classes. What you would see is the realization of our idea that social interactions between students and with their teachers is the “active” ingredient that works for us. You would see nine students at a 7' diameter round table—the

size and shape of the tables are very important—working in groups of three or collectively as a table-group of nine.

A short faculty “lecture” would present an interesting scenario for students to explore and would be followed by the instructor roaming around the classroom, engaging students and teams in Socratic-like dialogues. Students spend time on “tangibles” and “ponderables,” which means they are dealing with hands-on activities, simulations and complex problems.



We have integrated instructional technologies into this learning space, and each table has at least three networked laptops (probably not like a banquet hall, but something approaching real eating spaces on college campuses!). These notebook computers give students immediate connections to the resources of the world wide web.

From our own experiences and from research on learning, we knew that as students collaborate on interesting tasks they become deeply and personally involved with what they are learning. The doors of the closets and the walls of the classroom are covered with whiteboards—public thinking spaces—to help them share their learning with each other and their instructor.

### Photos courtesy of:

North Carolina State University, Robert Beichner  
Penn State Behrend, Jonathan Hall  
MIT, John Belcher

