Content, Assessment and Pedagogy: An Integrated Design Approach for OBE at the Course Level

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Workshop Layout

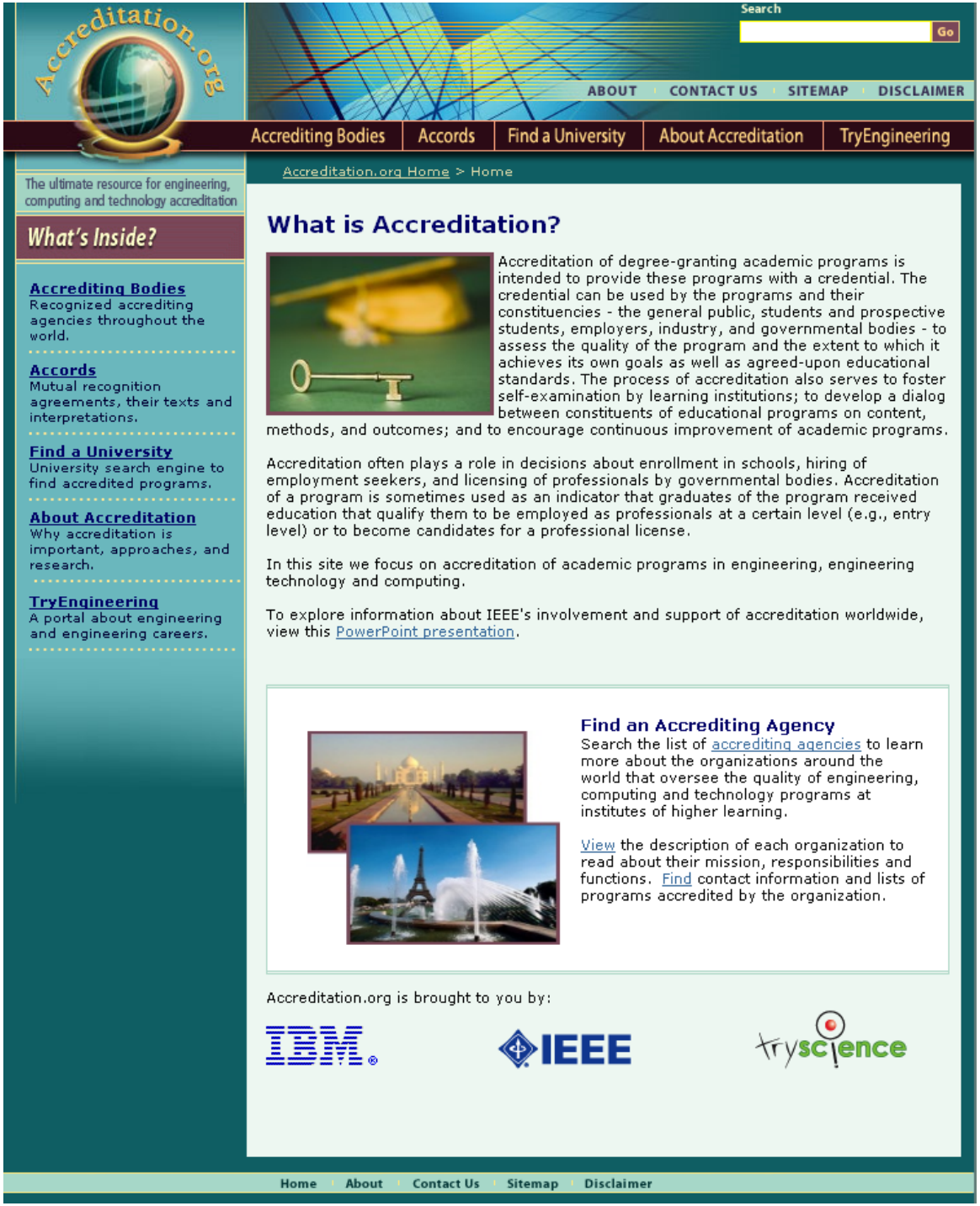
- Welcome & Overview
- Update on Engineering Accreditation
- Integrated Course Design (CAP Model)
  - Content
  - Assessment
  - Pedagogy
- Integrated Course Design Approaches
- Wrap-up and Next Steps

Session Objectives

- Participants will be able to describe key elements of:
  - Integrated course design – CAP model
  - Variety of integrated course design approaches
  - Teaching and Learning assessment strategies
- Participants will begin applying key elements to the design/re-design of a course

Background Knowledge Survey

- Level of Familiarity with
  - International Accreditation Outcomes
  - Approaches to Course Design
  - Assessment Strategies
  - Pedagogy
- Responsibility
  - Individual course
  - Program
  - Accreditation



Engineering Accreditation

Accreditation.org (shown at left)

Sample Outcome Criteria
- USA
- Japan
- Canada
- Ireland

Historical Developments
- Boeing – Employee Checklist
- Global Engineer

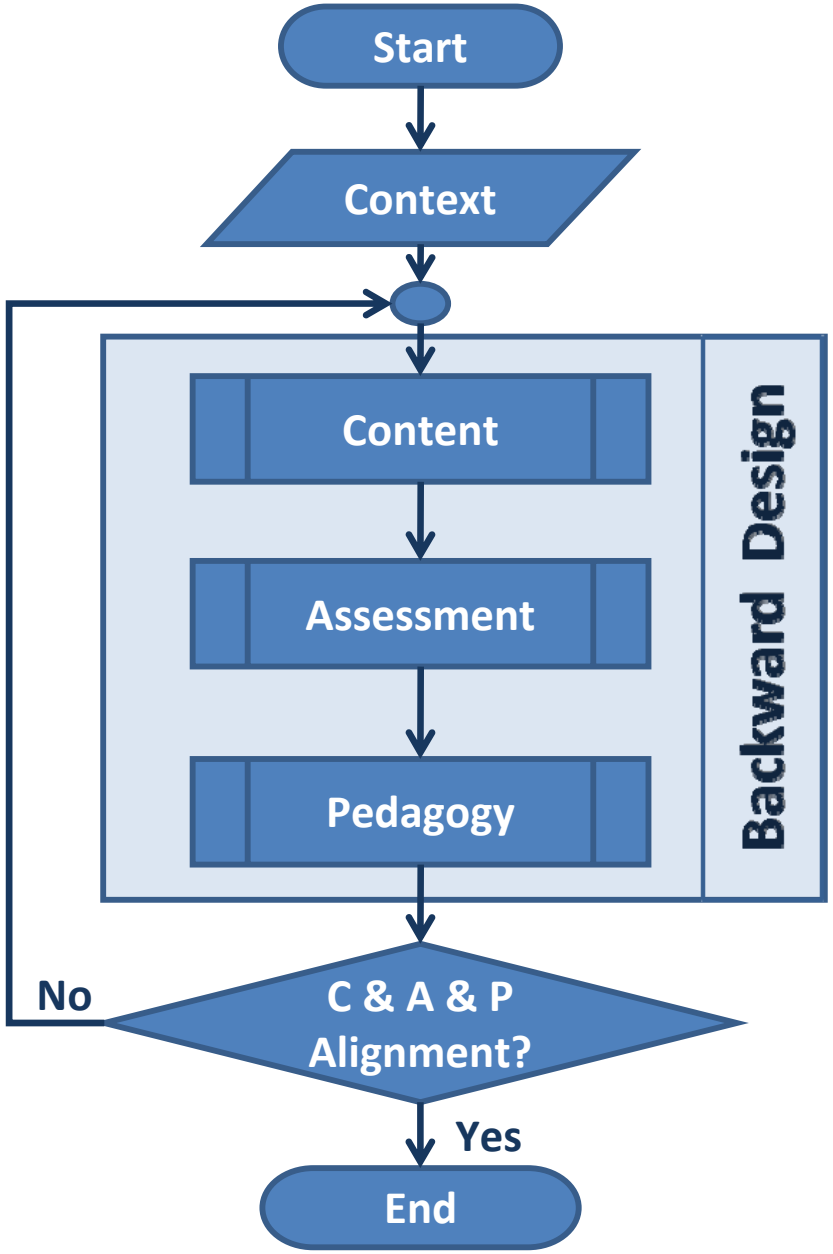
NAE Engineer of 2020 – Successful attributes

Purdue Future Engineer

It could well be that faculty members of the twenty-first century college or university will find it necessary to set aside their roles as teachers and instead become designers of learning experiences, processes, and environments.

James Duderstadt, 1999 [Nuclear Engineering Professor; Dean, Provost and President of the University of Michigan]

CAP Design Process Flowchart



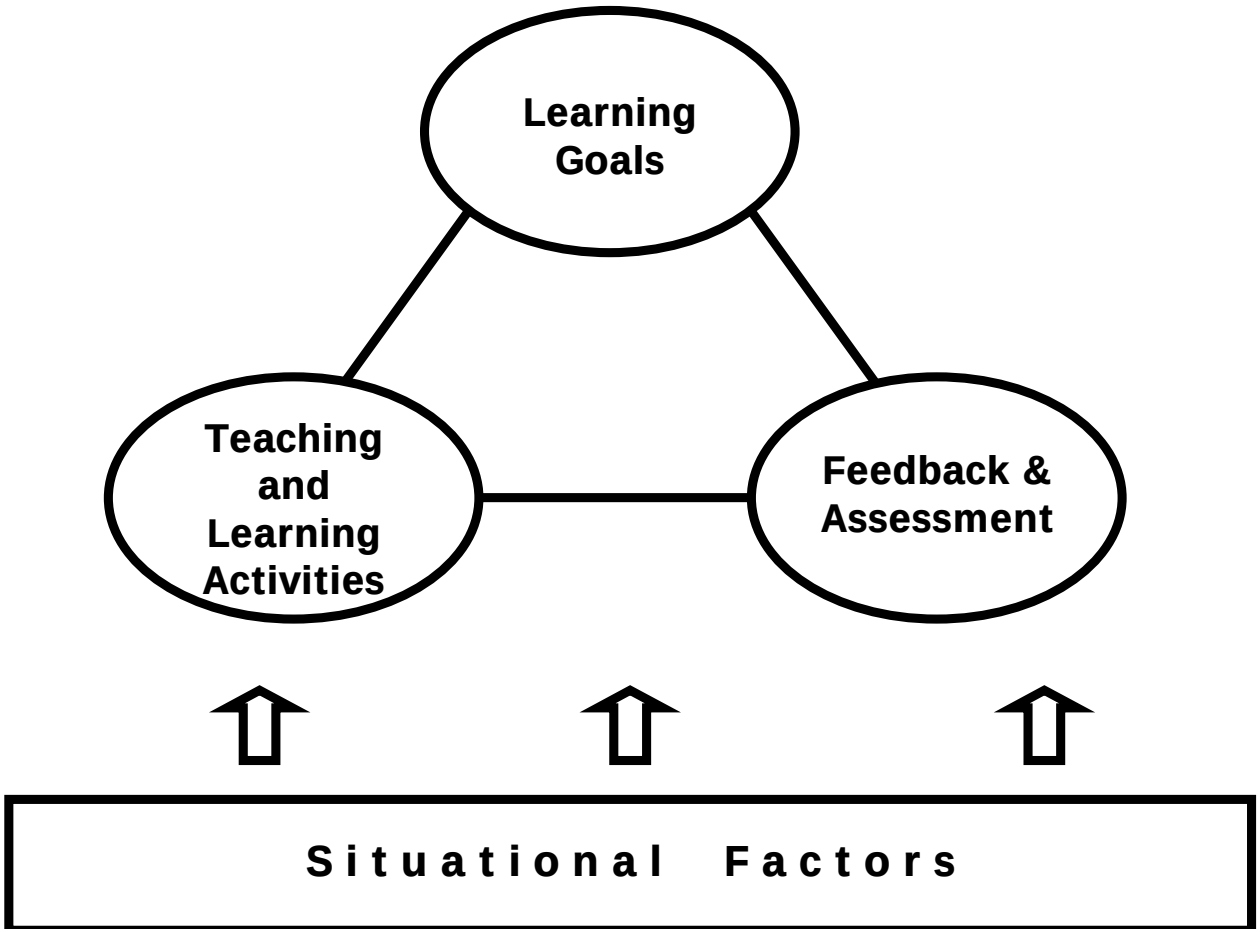
Integrated Course Design (Fink, 2003)

Initial Design Phase

1. Situational Factors
2. Learning Goals
3. Feedback and Assessment
4. Teaching/Learning Activities
5. Integration

Model 1

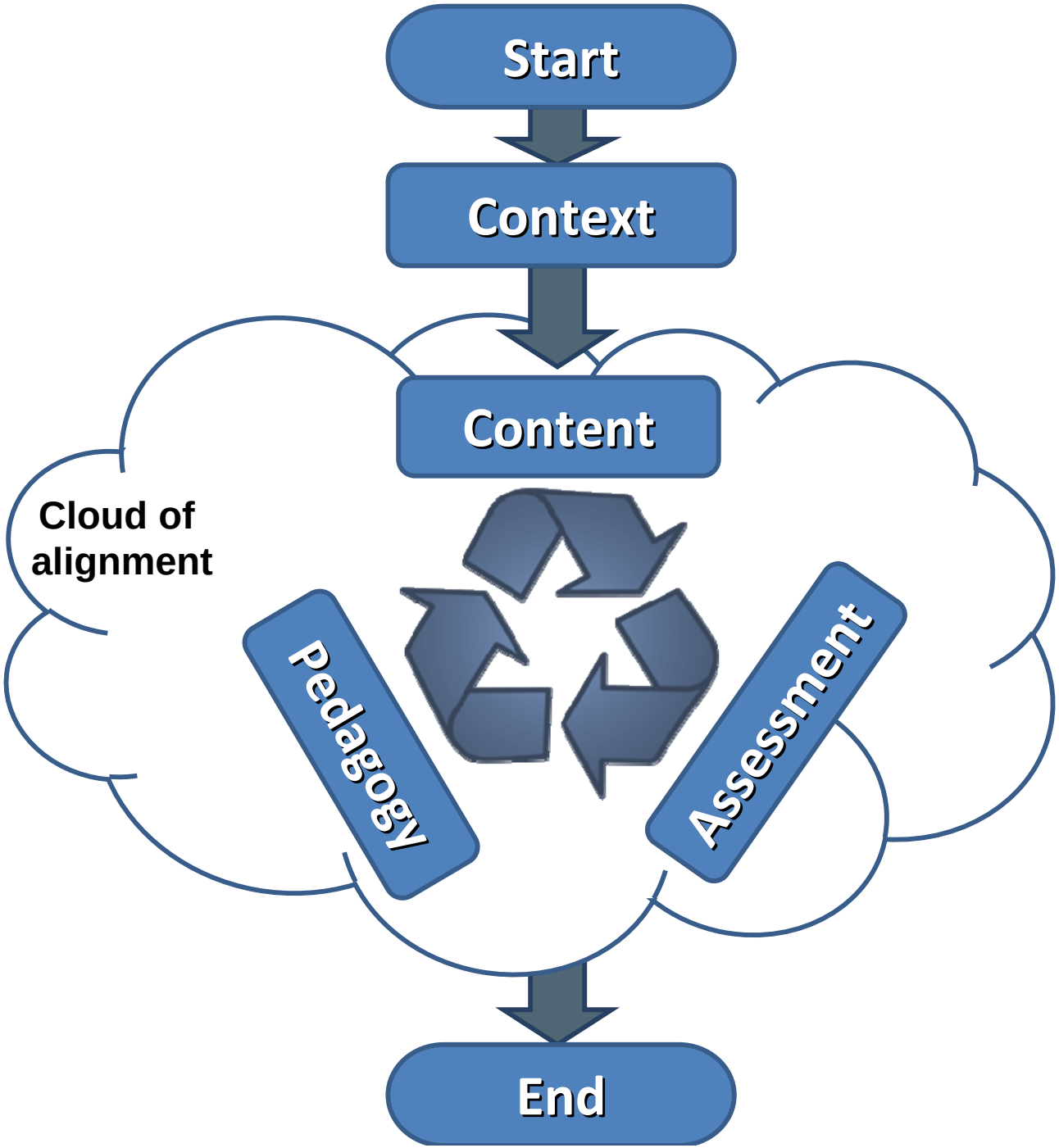
The Key Components Of INTEGRATED COURSE DESIGN



A Self-Directed Guide to Designing Courses for Significant Learning

L. Dee Fink. 2003. *Creating significant learning experiences*. Jossey-Bass.

CAP Design Process (Shawn's Model)



Resources

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Creating High-Quality Learning Environments: Guidelines from Research on How People Learn

*John Bransford, Nancy Vye, and Helen Bateman**

Not long ago, our local newspaper announced that the state university system was going to offer a number of college degree programs over the Internet. Some people scoffed at the idea and made statements like "here come the diploma mills." However, for a large number of individuals, this was genuinely exciting news. Some had attended college but did not get a chance to finish because they needed to go to work full-time—now they had a chance to get a degree. Others never had the chance to attend college—now they could do so without having to move from their present location. Even if it turns out that many of these people don't have the time to take enough courses to graduate, it can be a wonderful sense of accomplishment to have taken a college course or two.

We applaud the increased access to educational opportunities that new technologies are making possible. Nevertheless, we have been asked to focus on the issue of educational quality rather than access. Ultimately, people need access to high-quality learning opportunities. Issues of quality are important for face-to-face learning environments, totally online environments, and hybrid environments that include combinations of both.

We organize this chapter into three major sections:

*John Bransford is Centennial Professor of Psychology and codirector of the Learning Technology Center at Peabody College of Vanderbilt University. Nancy Vye is senior research associate and codirector of the Learning Center at Peabody College of Vanderbilt University. Helen Bateman is presently a research fellow at the Learning Technology Center, Vanderbilt University. This chapter is based on research funded by the National Science Foundation and the U.S. Department of Education.

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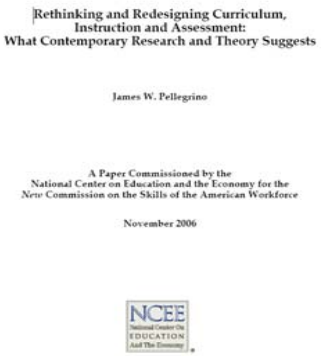
http://books.nap.edu/openbook.php?record_id=10239&page=159



Rethinking and Redesigning Curriculum, Instruction and Assessment: What Contemporary Research and Theory Suggests

James W. Pellegrino

A Paper Commissioned by the
National Center on Education and the Economy for the
New Commission on the Skills of the American Workforce

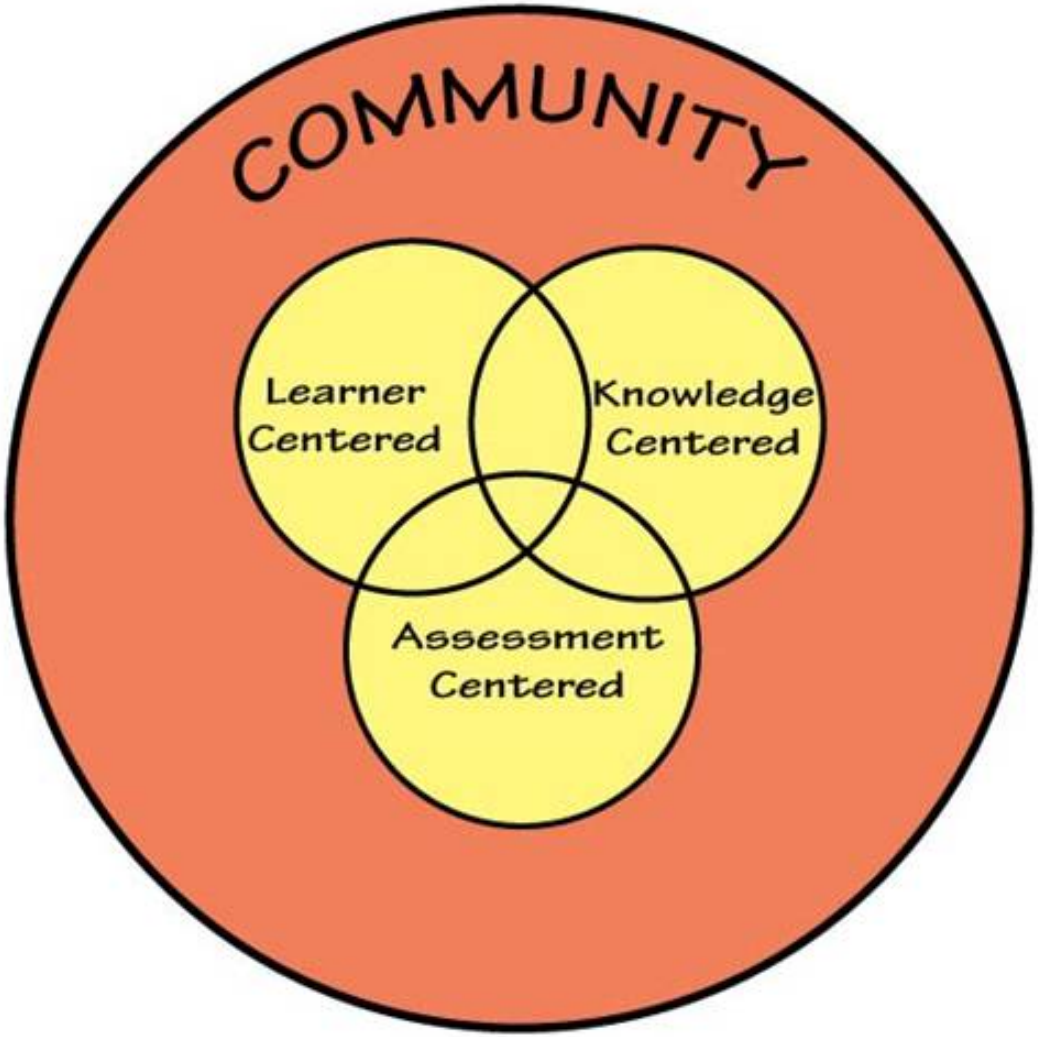
November 2006

NCEE
National Center On
EDUCATION
And The Economy

http://www.skillscommission.org/commissioned.htm

- Bransford, Vye and Bateman – Creating High Quality Learning Environments
- Pellegrino – Rethinking and Redesigning Curriculum, Instruction and Assessment

Designing Learning Environments Based on HPL (How People Learn)



Backward Design
Wiggins & McTighe

Stage 1. Identify Desired Results

Stage 2. Determine Acceptable Evidence

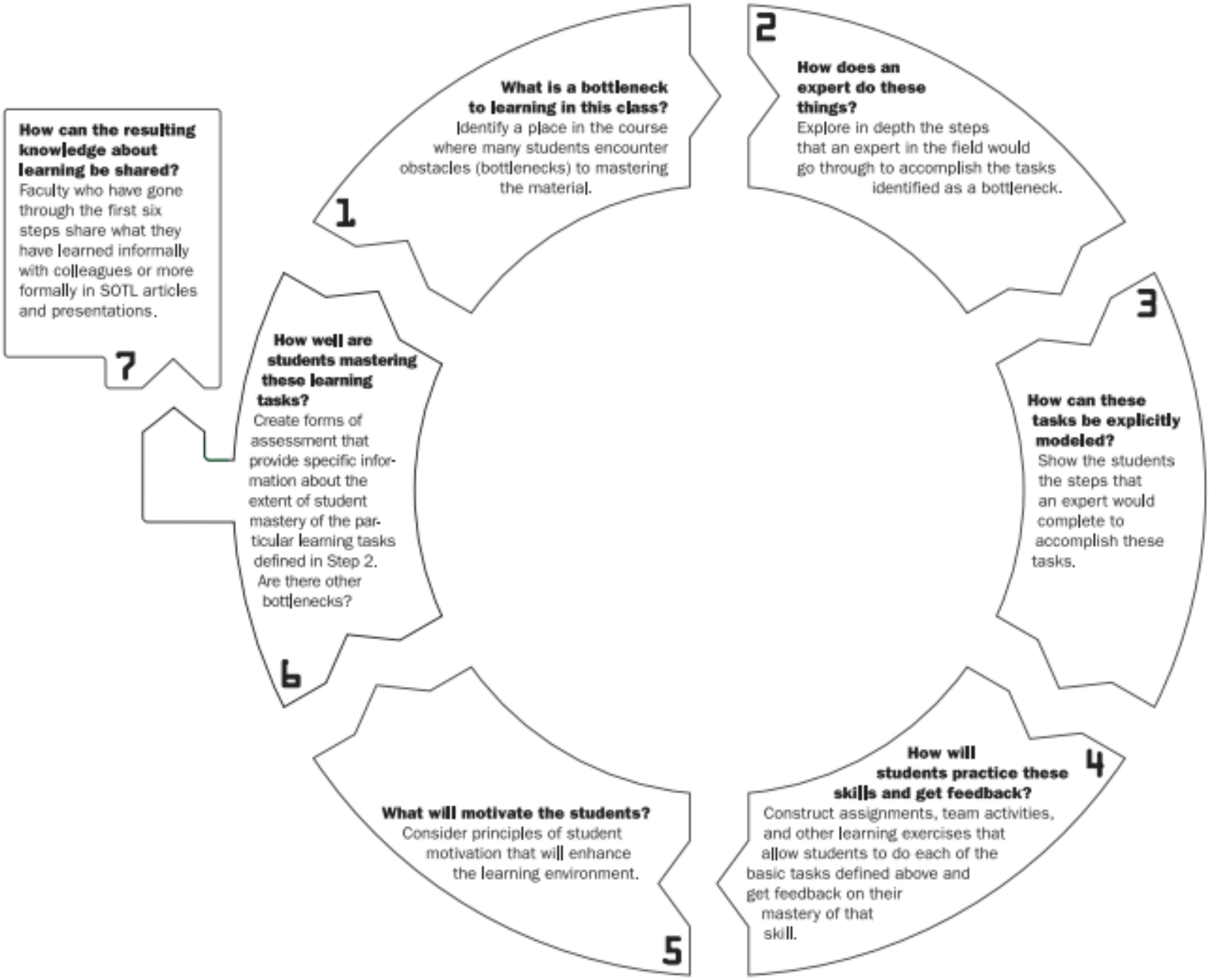
Stage 3. Plan Learning Experiences
and Instruction

Wiggins, Grant and McTighe, Jay. 1998. *Understanding by Design*. Alexandria, VA: ASCD

Content Resources

- Donald, Janet. 2002. *Learning to think: Disciplinary perspectives*. San Francisco: Jossey-Bass.
- Middendorf, Joan and Pace, David. 2004. Decoding the Disciplines: A Model for Helping Students Learn Disciplinary Ways of Thinking. *New Directions for Teaching and Learning, 98*.
- Krajcik, Joseph; McNeill, Katherine L.; Reiser, Brian J. 2008. Learning-Goals-Driven Design Model: Developing Curriculum Materials that Align with National Standards and Incorporate Project-Based Pedagogy. *Science Education, 92*(1), 1-32.

Figure 1.1. Decoding the Disciplines: Seven Steps to Overcome Obstacles to Learning



Worksheet 1

Worksheet for Designing a Course/Class Session/Learning Module

	Ways of Assessing	Actual Teaching-Learning	Helpful Resources:
Learning Goals for Course/Session/Module:	**This Kind of Learning:**	**Activities:**	(e.g., people, things)
1.			
2.			
3.			
4.			
5.			
6.			

Backward Design

Stage 1. Identify Desired Results

Filter 1. To what extent does the idea, topic, or process represent a big idea or having enduring value beyond the classroom?

Filter 2. To what extent does the idea, topic, or process reside at the heart of the discipline?

Filter 3. To what extent does the idea, topic, or process require uncoverage?

Filter 4. To what extent does the idea, topic, or process offer potential for engaging students?

Understanding Understanding

Stage 1. Identify Desired Results
Focus Question: What does it mean to "understand"?

Stage 2. Determine Acceptable Evidence
Focus Questions: "How will we know if students have achieved the desired results and met the standards? What will we accept as evidence of student understanding and proficiency (Wiggins & McTighe)

Understanding Misunderstanding

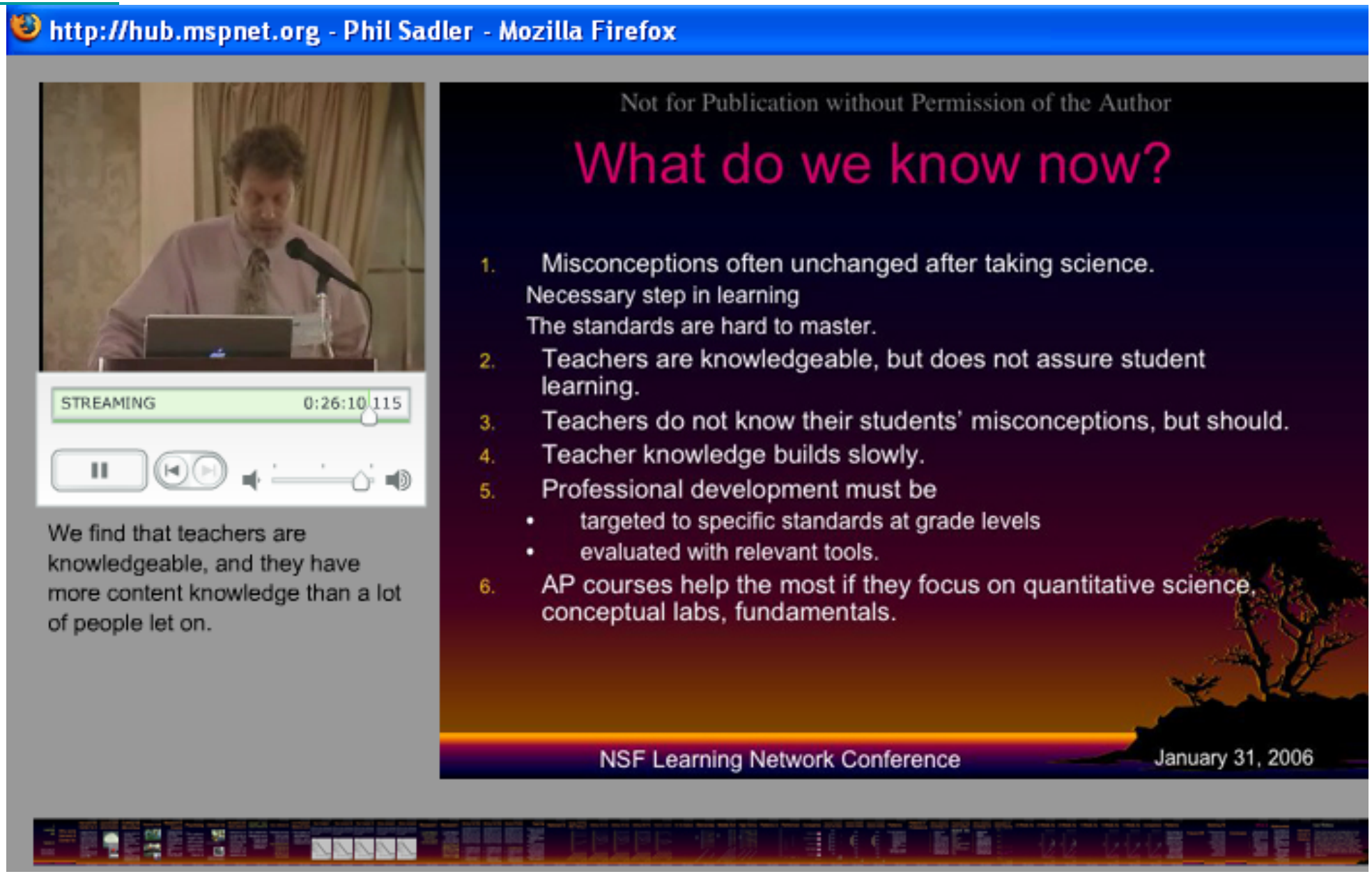
A Private Universe – 21 minute video available from www.learner.org

Also see *Minds of our own* (Annenberg/CPB Math and Science Collection – www.learner.org)

1. Can we believe our eyes?
2. Lessons from thin air
3. Under construction

Teaching Teaching & Understanding Understanding - http://www.daimi.au.dk/~brabrand/short-film/index-gv.html

The Interaction Between the Science Content Knowledge of Teachers and Their Students



http://hub.mspnet.org/index.cfm/12746

Taxonomies

Bloom's taxonomy of educational objectives: Cognitive Domain (Bloom & Krathwohl, 1956)

A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives (Anderson & Krathwohl, 2001).

Evaluating the quality of learning: The SOLO taxonomy (Biggs & Collis, 1982)

Facets of understanding (Wiggins & McTighe, 1998)

Taxonomy of significant learning (Fink, 2003)

A taxonomic trek: From student learning to faculty scholarship (Shulman, 2002)

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements						
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures						
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures						
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge						

3.1 The Taxonomy Table

The Knowledge Dimension	The Cognitive Process Dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual knowledge						
B. Conceptual knowledge						
C. Procedural knowledge						
D. Meta-cognitive knowledge						

(Anderson & Krathwohl, 2001).

The Cognitive Process Dimension

Remember	Understand	Apply	Analyze	Evaluate	Create
Retrieving relevant knowledge from long-term memory	Determining the meaning of instructional messages, including oral, written, and graphic communication.	Carrying out or using a procedure in a given situation	Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose	Making judgments based on criteria and standards	Putting elements together to form a novel, coherent whole or make an original product
Recall Define Relate Review	Restate Describe Identify Express	Employ Translate Demonstrate Examine	Distinguish Compare Contrast Deduce	Select Defend Interpret Discriminate	Arrange Combine Construct Propose

The Knowledge Dimension

Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it.

a. Knowledge of terminology

b. Knowledge of specific details and elements

Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together.

a. Knowledge of classifications and categories

b. Knowledge of principles and generalizations

c. Knowledge of theories, models, and structures

Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.

a. Knowledge of subject-specific skills and algorithms

b. Knowledge of subject-specific techniques and methods

c. Knowledge of criteria for determining when to use appropriate procedures

Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.

a. Strategic knowledge

b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge

c. Self-knowledge

Facets of Understanding
Wiggins & McTighe, 1998, page 44

When we truly understand,we

Can ***explain***

Can ***interpret***

Can ***apply***

Have ***perspective***

Can ***empathize***

Have ***self-knowledge***

SIX FACETS OF UNDERSTANDING

Six Facets	Description	Example
Explanation	To ensure students understand why an answer or approach is the right one. Students explain or justify their responses or justify their course of action.	Students develop an illustrated brochure to explain the principles and practices of a particular type of technology (i.e., transportation, construction, medical, information).
Interpretation	To ensure students avoid the pitfall of looking for the "right answer" and demand answers that are principled…students are able to encompass as many salient facts and points of view as possible.	Students develop a 'biography' of the development of a particular type of technology.
Application	To ensure students' key performances are conscious and explicit reflection, self-assessment, and self-adjustment, with reasoning made evident. Authentic assessment requires a real or simulated audience, purpose, setting, and options for personalizing the work, realistic constraints, and "background noise."	Students analyze a design of a product, taking it apart in order to determine how it works. Students design, develop, test, and revise a solution to a local issue, such as a new roadway system, a water treatment system, or long-term storage of various materials.
Perspective	To ensure students know the importance or significance of an idea and to grasp its importance or unimportance. Encourage students to step back and ask, "What of it?" "Of what value is this knowledge?" "How important is this idea?" "What does this idea enable us to do that is important?"	Students investigate about a technological artifact from the perspective of different regions and countries.
Empathy	To ensure students develop the ability to see the world from different viewpoints in order to understand the diversity of thought and feeling in the world.	Students imagine they are politicians debating the value of nuclear power. They write their thoughts and feelings explaining why they agree or disagree with the use of nuclear power.
Self-Knowledge	To ensure students are deeply aware of the boundaries of their own and others' understanding; able to recognize their own prejudices and projections; has integrity – able and willing to act on what one understands	Students reflect on their own progress of understanding about one of the standards in *Standards for Technological Literacy: Content for the Study of Technology*. They evaluate the extent to which they have improved, what task or assignment was the most challenging and why, and which project or product of work they are most proud of and why.

Source: Wiggins, G., & McTighe, J. (1998). *Understanding by Design*. p. 85-97. Alexandria, VA: Association for Supervision and Curriculum Development

A TAXONOMY OF SIGNIFICANT LEARNING

1. Foundational Knowledge

- "Understand and remember" learning

  For example: facts, terms, formulae, concepts, principles, etc.

2. Application

- Thinking: critical, creative, practical (problem-solving, decision-making)
- Other skills

  For example: communication, technology, foreign language
- Managing complex projects

3. Integration

- Making "connections" (i.e., finding similarities or interactions) . . .

  Among: ideas, subjects, people

4. Human Dimensions

- Learning about and changing one's SELF
- Understanding and interacting with OTHERS

5. Caring

- Identifying/changing one's feelings, interests, values

6. Learning How to Learn

- Becoming a better student
- Learning how to ask and answer questions
- Becoming a self-directed learner

Backward Design

Stage 2. **Determine Acceptable Evidence**

Types of Assessment

Quiz and Test Items:

Simple, content-focused test items

Academic Prompts:

Open-ended questions or problems that require the student to think critically

Performance Tasks or Projects:

Complex challenges that mirror the issues or problems faced by graduates, they are authentic

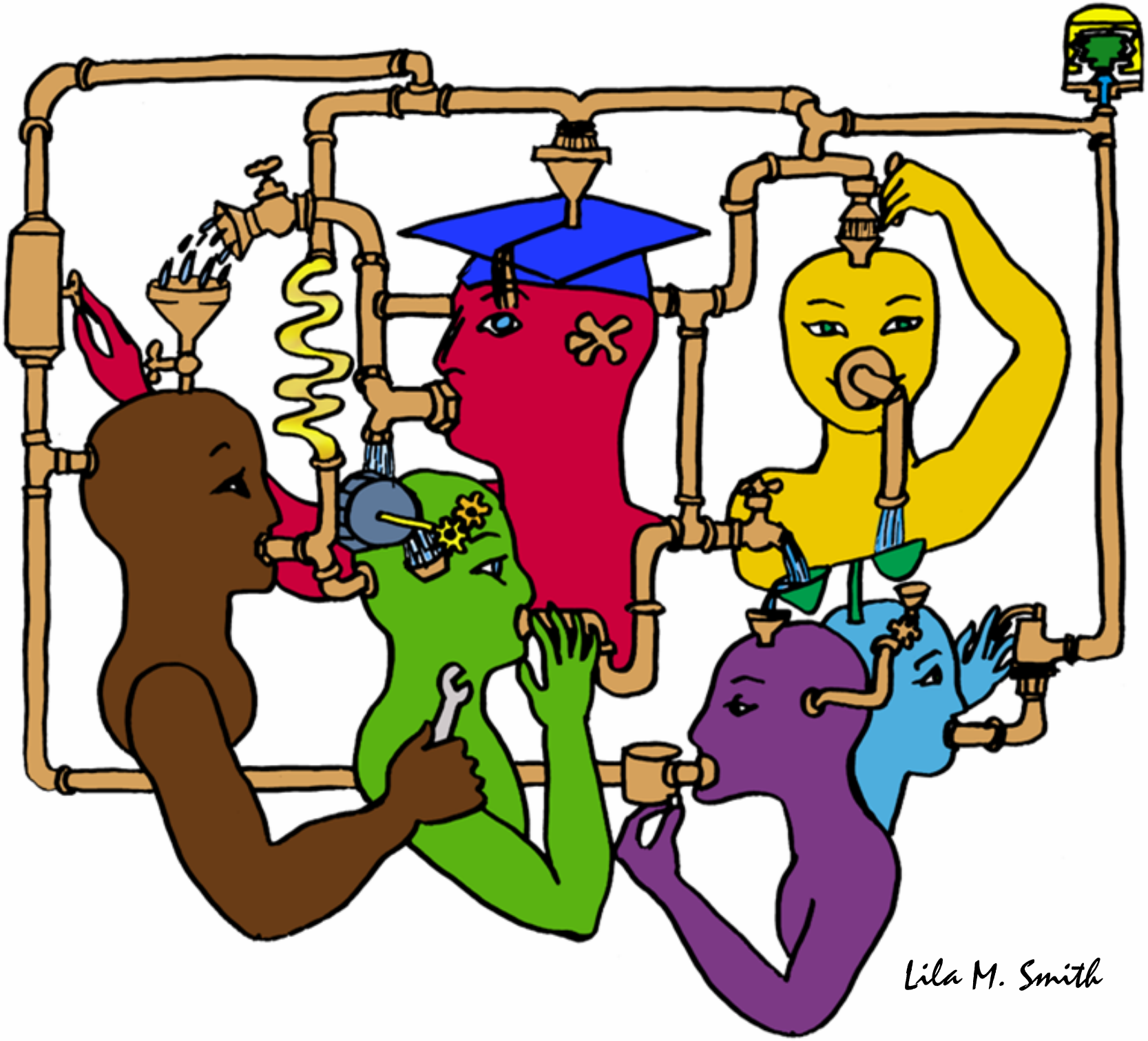
Backward Design

Stage 3. Plan Learning Experiences & Instruction

- What enabling knowledge (facts, concepts, and principles) and skills (procedures) will students need to perform effectively and achieve desired results?
- What activities will equip students with the needed knowledge and skills?
- What will need to be taught and coached, and how should it be taught, in light of performance goals?
- What materials and resources are best suited to accomplish these goals?
- Is the overall design coherent and effective?

Pedagogies of Engagement

Lila M. Smith


Lila M. Smith

MIT & Harvard – Engaged Pedagogy

At M.I.T., Large Lectures Are Going the Way of the Blackboard

Jodi Hilton for The New York Times

The Massachusetts Institute of Technology has changed the way it offers some introductory classes. Prof. Gabriella Sciolla at a class on electricity and magnetism.

By SARA RIMER
Published: January 12, 2009

COMMENTS (66)
E-MAIL
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SINGLE PAGE

CAMBRIDGE, Mass. — For as long as anyone can remember, introductory physics at the Massachusetts Institute of Technology was taught in a vast windowless amphitheater known by its number,

January 13, 2009—New York Times
http://www.nytimes.com/2009/01/13/us/13physics.html?em

EDUCATION

Farewell, Lecture?

A physics professor describes his evolution from lecturing to dynamically engaging students during class and improving how they learn.

Eric Mazur

Discussions of education are generally predicated on the assumption that we know what education is. I hope to convince you otherwise by recounting some of my own experiences. When I started teaching introductory physics to undergraduates at Harvard University, I never asked myself how I would educate my students. I did what my teachers had done—I lectured. I thought that was how one learns. Look around anywhere in the world and you'll find lecture halls filled with students and, at the front, an instructor. This approach to education has not changed since before the Renaissance and the birth of scientific inquiry. Early in my career I received the first hints that something was wrong with teaching in this manner, but I had ignored it. Sometimes it's hard to face reality.

When I started teaching, I prepared lecture notes and then taught from them. Because my lectures deviated from the textbook, I provided students with copies of these lecture notes. The infuriating result was that on my end-of-semester evaluations—which were quite good otherwise—a number of students complained that I was "lecturing straight from (his) lecture notes." What was I supposed to do? Develop a set of lecture notes different from the ones I handed out? I decided to ignore the students' complaints.

Department of Physics, Harvard University, Cambridge, MA 02138, USA. E-mail: mazur@physics.harvard.edu

Click here. Students continually discuss concepts among themselves and with the instructor during class. Discussions are spurred by multiple-choice conceptual questions that students answer using a clicker device. See supporting online text for examples of such "clicker questions."

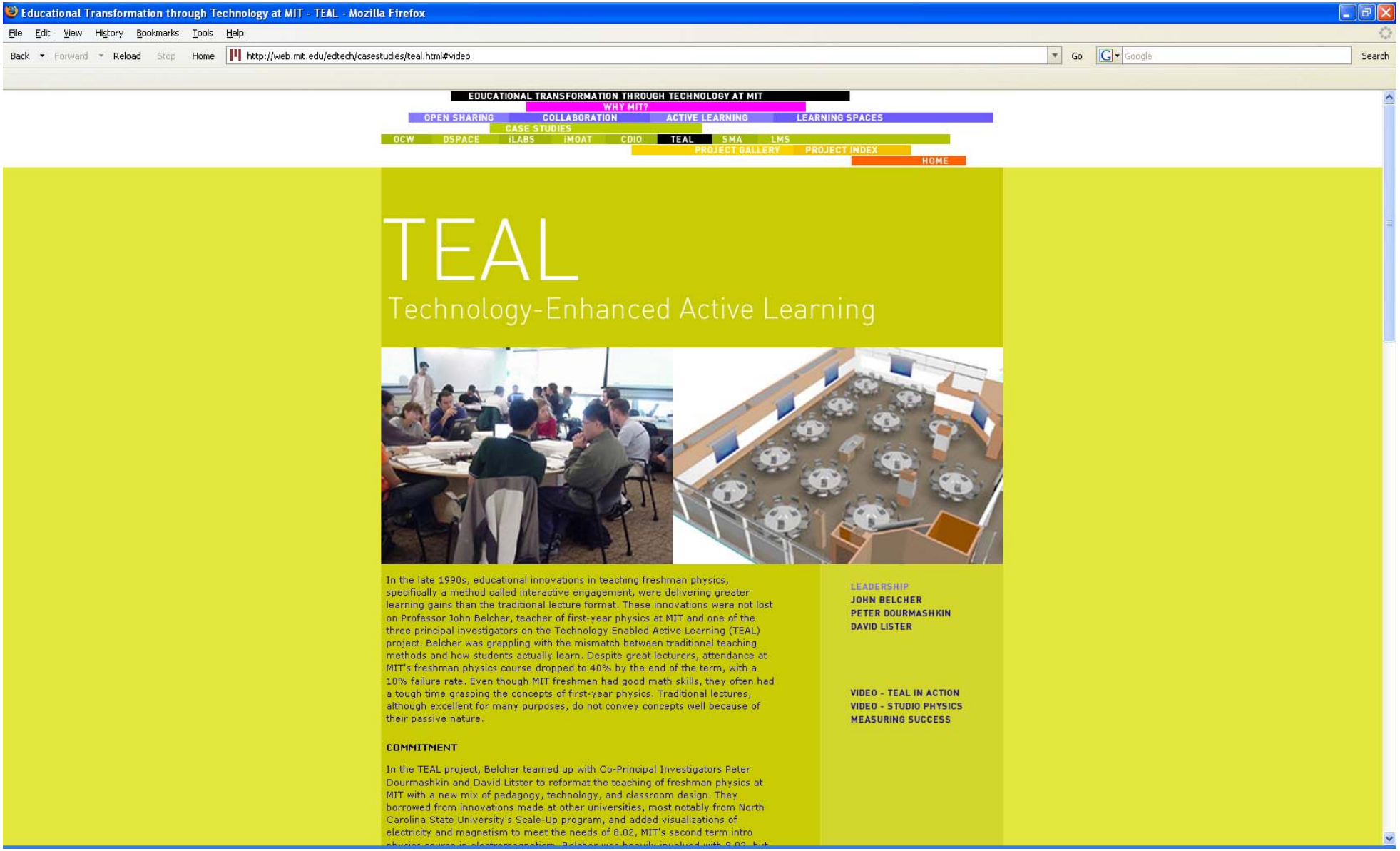
A few years later, I discovered that the students were right. My lecturing was ineffective, despite the high evaluations. Early on in the physics curriculum—in week 2 of a typical introductory physics course—the Laws of Newton are presented. Every student in such a course can recite Newton's third law of motion, which states that the force of object A on object B in an interaction between two objects is equal in magnitude to the force of B on A—it sometimes is known as "action is reaction." One day, when the course had progressed to more complicated material, I decided to test my students' understanding of this concept not by doing traditional problems, but by asking them a set of basic conceptual questions (*1*, *2*). One of the questions, for example, requires students to compare the forces that a heavy truck and a light car exert on one another when they collide. I expected that the students would have no trouble tackling such questions, but much to my surprise, hardly a minute after the test began, one student asked, "How should I answer these questions? According to what you taught me or according to the way I usually think about these things?" To my dismay, students had great difficulty with the conceptual questions. That was when it began to dawn on me that something was amiss.

In hindsight, the reason for my students' poor performance is simple. The traditional approach to teaching reduces education to a transfer of information. Before the industrial revolution, when books were not yet mass commodities, the lecture method was the only way to transfer information from one generation to the next. However, education is so

ORDER (BOTTOM) JORCHASE/HARVARD UNIVERSITY

January 2, 2009—Science, Vol. 323
www.sciencemag.org

Calls for evidence-based teaching practices



http://web.mit.edu/edtech/casestudies/teal.html#video

NC STATE UNIVERSITY

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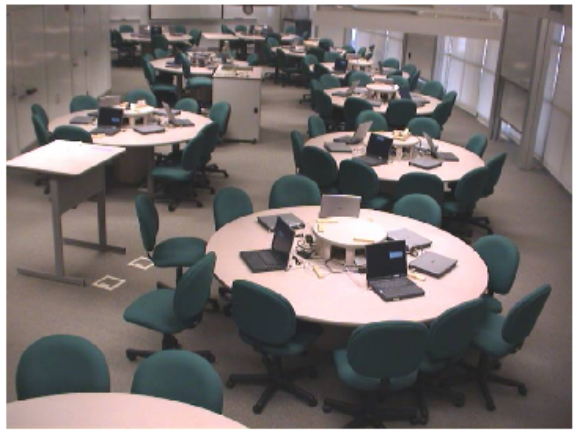


About the SCALE-UP Project...

This research was supported, in part, by the U.S. Department of Education's Fund for the Improvement of Post-Secondary Education (FIPSE), the National Science Foundation, Hewlett-Packard, Apple Computer, and Pasco Scientific. Opinions expressed are those of the authors and not necessarily those of our sponsors.

The primary goal of the Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project is to establish a highly collaborative, hands-on, computer-rich, interactive learning environment for large-enrollment courses.

Educational research indicates that students should collaborate on interesting tasks and be deeply involved with the material they are studying. We promote active learning in a redesigned classroom of 100 students or more. (Of course, smaller classes can also benefit.) We believe the SCALE-UP Project has the potential to radically change the way large classes are taught at colleges and universities. The social interactions between students and with their teachers appears to be the "active ingredient" that make the approach work. As more and more instruction is handled virtually via technology, the relationship-building capability of brick and mortar institutions becomes even more important. The pedagogical methods and classroom management techniques we design and disseminate are general enough to be used in a wide variety of classes at many different types of colleges.

Classtime is spent primarily on "tangibles" and "ponderables ". Essentially these are hands-on activities, simulations, or interesting questions and problems. There are also some hypothesis-driven labs where students have to write detailed reports. (This example is more sophisticated than most, but shows what the best students are capable of doing.) Students sit in three groups of three students at 6 or 7 foot diameter round tables. Instructors circulate and work with teams and individuals, engaging them in Socratic-like dialogues. Each table has at least three networked laptops. The setting is very much like a banquet hall, with lively interactions nearly all the time. Many other colleges and universities are adopting/adapting the SCALE-UP room design and pedagogy. Engineering schools are especially pleased with the course objectives, which fit in well with the requirements for ABET accreditation.

Materials developed for the course were incorporated into what became the leading introductory physics textbook, used by more than 1/3 of all science, math, and engineering students in the country.

Impact

Rigorous evaluations of learning have been conducted in parallel with the curriculum development effort. Besides hundreds of hours of classroom video and audio recordings, we also have conducted numerous interviews and focus groups, conducted many conceptual learning assessments (using nationally-recognized instruments in a pretest/posttest protocol), and collected portfolios of student work. We have data comparing nearly 16,000 traditional and SCALE-UP students. Our findings can be summarized as the following:

- Ability to solve problems is improved
- Conceptual understanding is increased
- Attitudes are improved
- Failure rates are drastically reduced, especially for women and minorities
- "At risk" students do better in later engineering statics classes

Details

A chapter describing the approach and its underpinnings is available. A shorter description is posted on the PKAL website, or you can view an article describing the project from the proceedings of the Sigma Xi Forum on Reforming Undergraduate Education. The Raleigh *News & Observer* newspaper also has a description of the project. The very successful pilot project was described in the first issue of the Physics Education Research supplement to Am. J. of Physics. See our publication page for more informatiion.

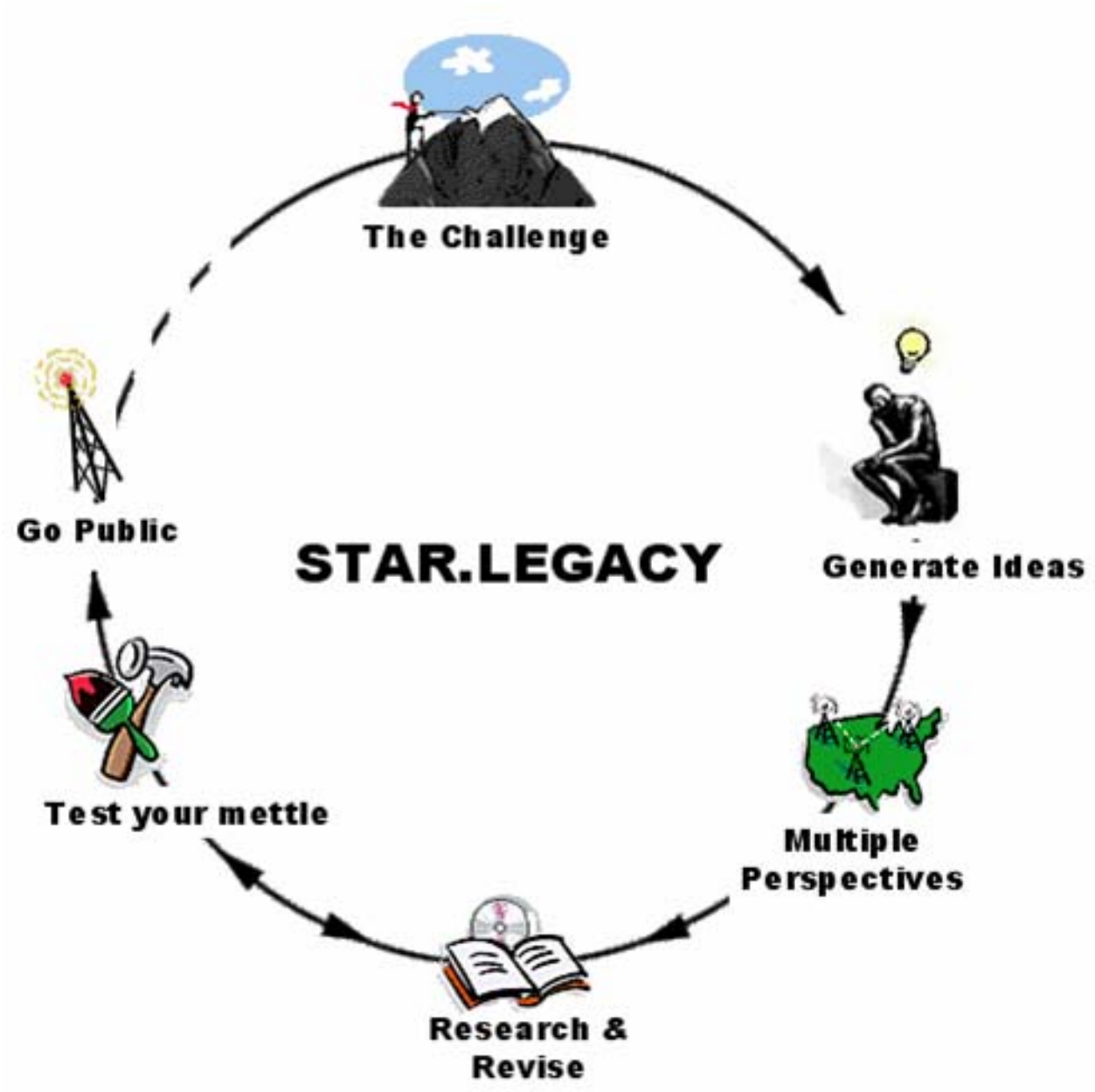
More than 50 colleges and universities across the US have adapted the SCALE-UP approach to their own institutions. In all cases, the basic idea remains the same: get the students working together to examine something interesting. That frees the instructor to roam about the room, asking questions and stirring up debates. Classes in physics, chemistry, math, engineering, and even literature have been taught this way. If you want more information, please contact Dr. Robert Beichner.

http://www.ncsu.edu/PER/scaleup.html

Challenged-Based Learning

- Problem-based learning
- Case-based learning
- Project-based learning
- Learning by design
- Inquiry learning
- Anchored instruction

John Bransford, Nancy Vye and Helen Bateman. Creating High-Quality Learning Environments: Guidelines from Research on How People Learn



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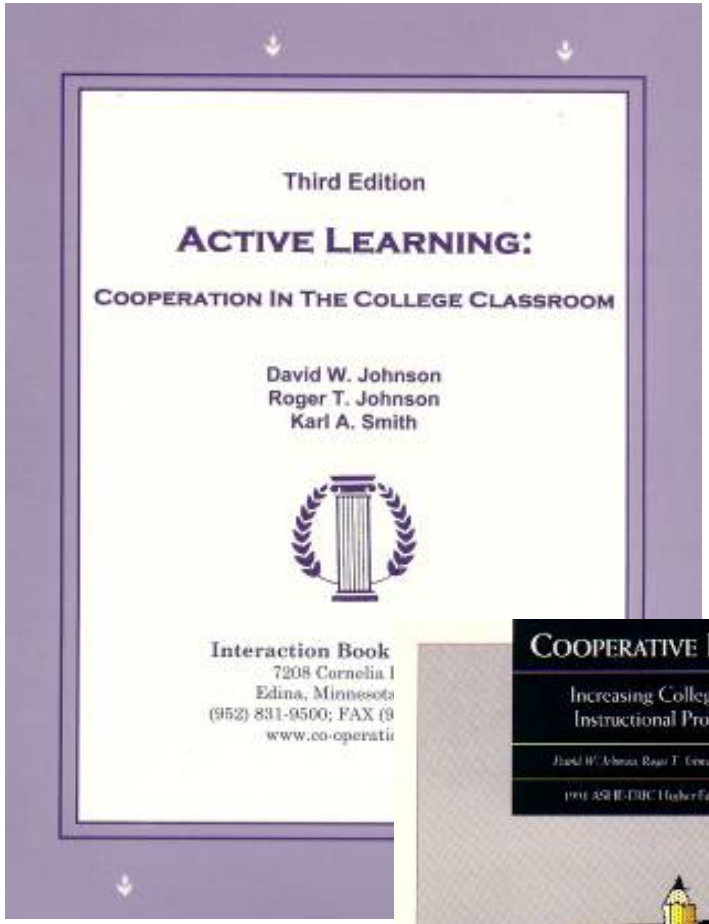


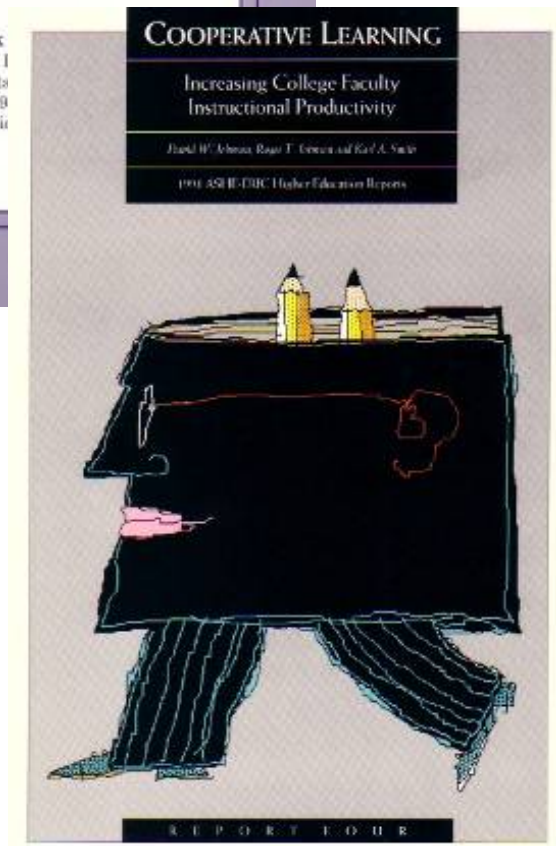
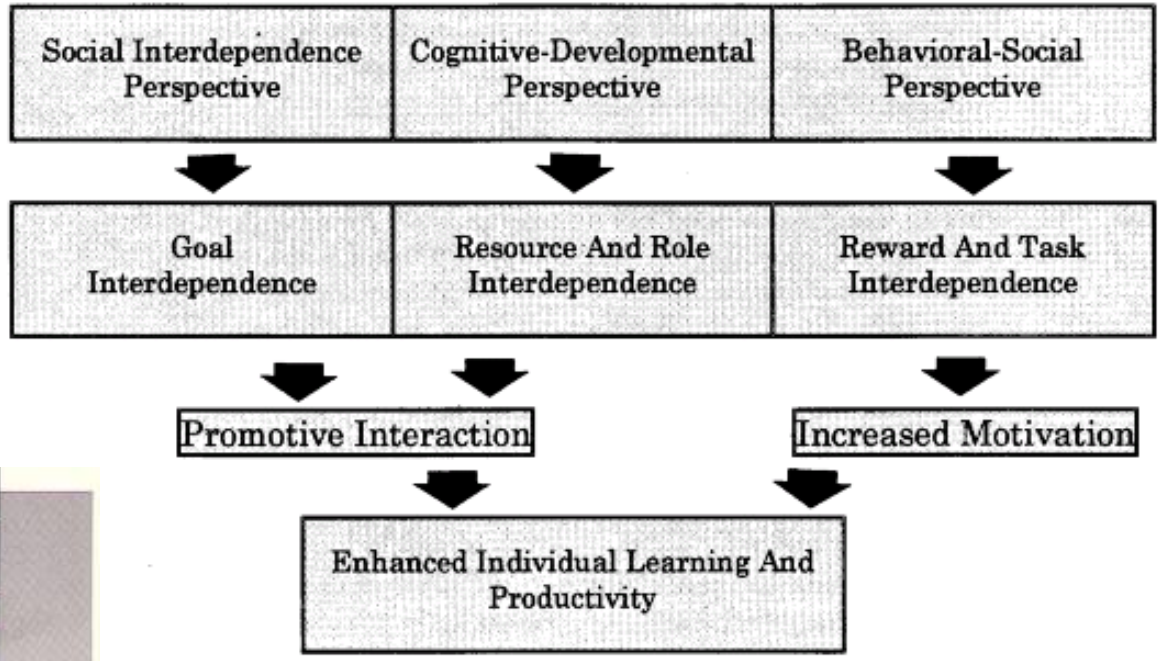


Figure A.1 A General Theoretical Framework



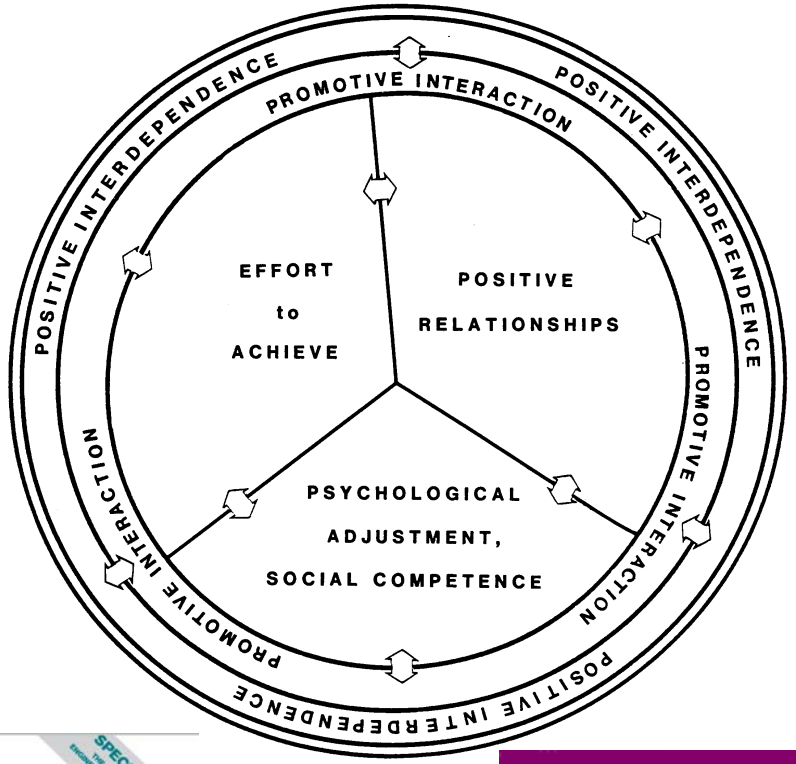
Cooperative Learning

- Positive Interdependence
- Individual and Group Accountability
- Face-to-Face Promotive Interaction
- Teamwork Skills
- Group Processing

Cooperative Learning Research Support

Johnson, D.W., Johnson, R.T., & Smith, K.A. 1998. Cooperative learning returns to college: What evidence is there that it works? *Change*, *30* (4), 26-35.

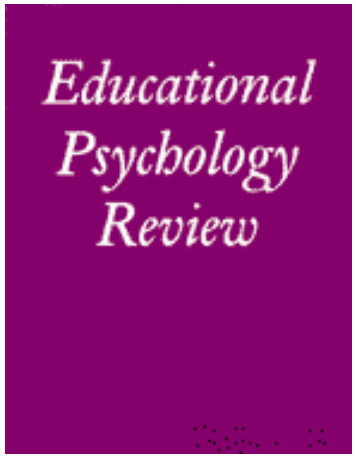
- Over 300 Experimental Studies
- First study conducted in 1924
- High Generalizability
- Multiple Outcomes



Outcomes

1. Achievement and retention
2. Critical thinking and higher-level reasoning
3. Differentiated views of others
4. Accurate understanding of others' perspectives
5. Liking for classmates and teacher
6. Liking for subject areas
7. Teamwork skills

January 2005



March 2007

Faculty interest in higher levels of inquiry in engineering education

- **Level 0** Teacher
  - Teach as taught
- **Level 1** Effective Teacher
  - Teach using accepted teaching theories and practices
- **Level 2** Scholarly Teacher
  - Assesses performance and makes improvements
- **Level 3** Scholar of Teaching and Learning
  - Engages in educational experimentation, shares results
- **Level 4** Engineering Education Researcher
  - Conducts educational research, publishes archival papers

Source: Streveler, R., Borrego, M. and Smith, K.A. 2007. Moving from the "Scholarship of Teaching and Learning" to "Educational Research:" An Example from Engineering. *Improve the Academy,* Vol. 25, 139-149.

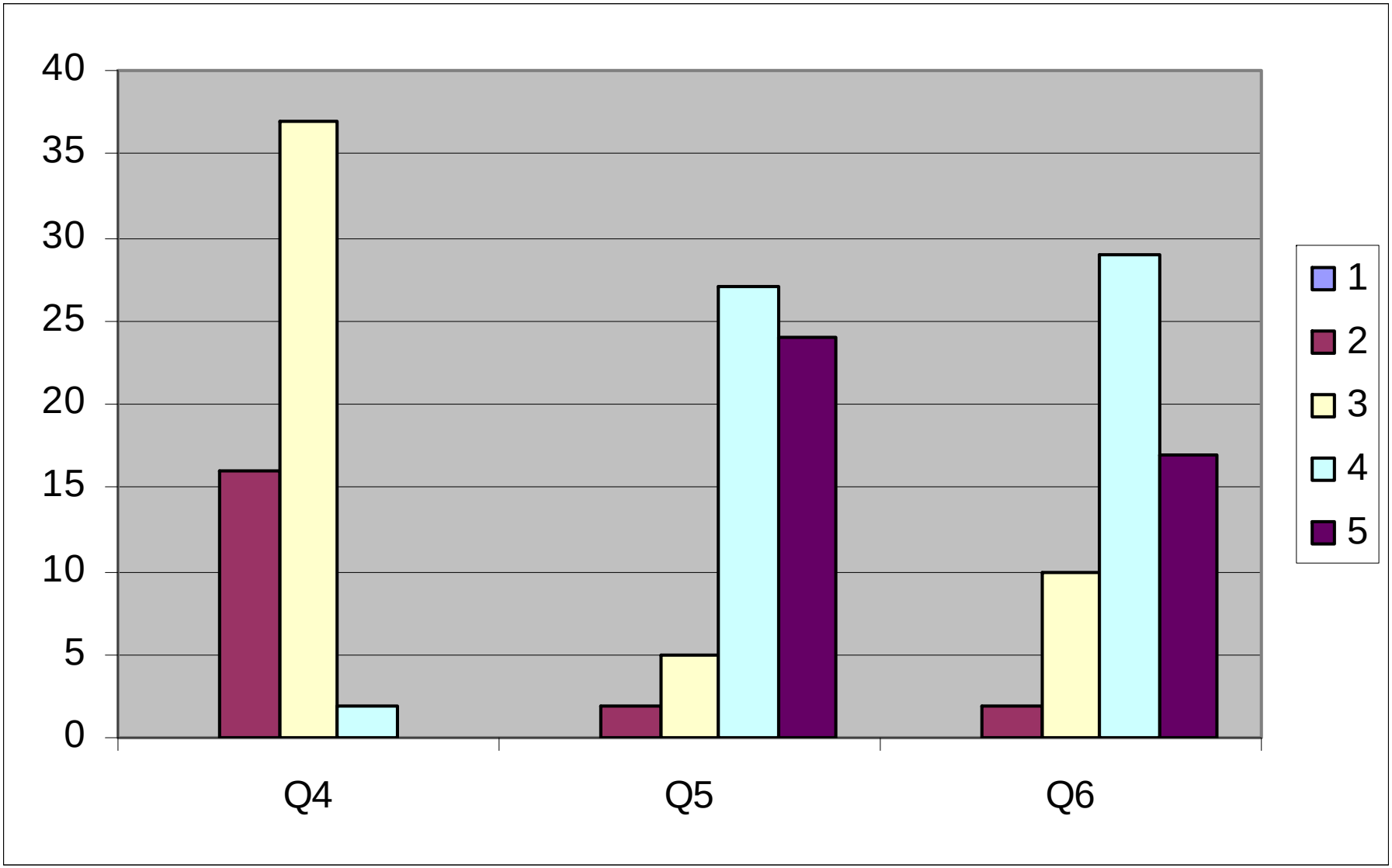
Session Summary
(Minute Paper)

Reflect on the session:

1. Most interesting, valuable, useful thing you learned.
2. One thing you'd be willing to try
3. Questions/Comments

4. Pace: Too slow 1 . . . . 5 Too fast
5. Relevance: Little 1 . . . 5 Lots
6. Instructional Format: Ugh 1 . . . 5 Ah

HKUST – February 6, 2009



Q4 – Pace: Too slow 1 . . . . 5 Too fast (2.7)
Q5 – Relevance: Little 1 . . . 5 Lots (4.3)
Q6 – Format: Ugh 1 . . . 5 Ah (4.1)