Cooperative Learning and the New Paradigm for Engineering Education

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Pathways to Change: Accreditation in Computing and Applied Sciences, Engineering & Technology Education

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Faculty Members' Role in a "learner-centered classroom"

- Lose the podium?
- Share the podium?
- Remove the podium?
- Share the intellectual workspace?

To teach is to engage students in learning; thus teaching consists of getting students involved in the active construction of knowledge. A teacher requires not only knowledge of subject matter, but knowledge of how students learn and how to transform them into active learners. Good teaching, then, requires a commitment to systematic understanding of learning. . .The aim of teaching is not only to transmit information, but also to transform students from passive recipients of other people's knowledge into active constructors of their own and others' knowledge. The teacher cannot transform without the student's active participation, of course. Teaching is fundamentally about creating the pedagogical, social, and ethical conditions under which students agree to take charge of their own learning, individually and collectively

Education for judgment: The artistry of discussion leadership . Edited by C. Roland Christensen, David A. Garvin, and Ann Sweet. Cambridge, MA: Harvard Business School, 1991.

Getting Students Involved Using Cooperative Learning Principles, Strategies, and Problem-Solving

Cooperative Learning:
What is it? How do you do it? Why bother?

Cooperative Learning is instruction that involves people working in teams to accomplish a common goal, under conditions that involve both *positive interdependence* (all members must cooperate to complete the task) and *individual and group accountability* (each member is accountable for the complete final outcome).

Key Concepts

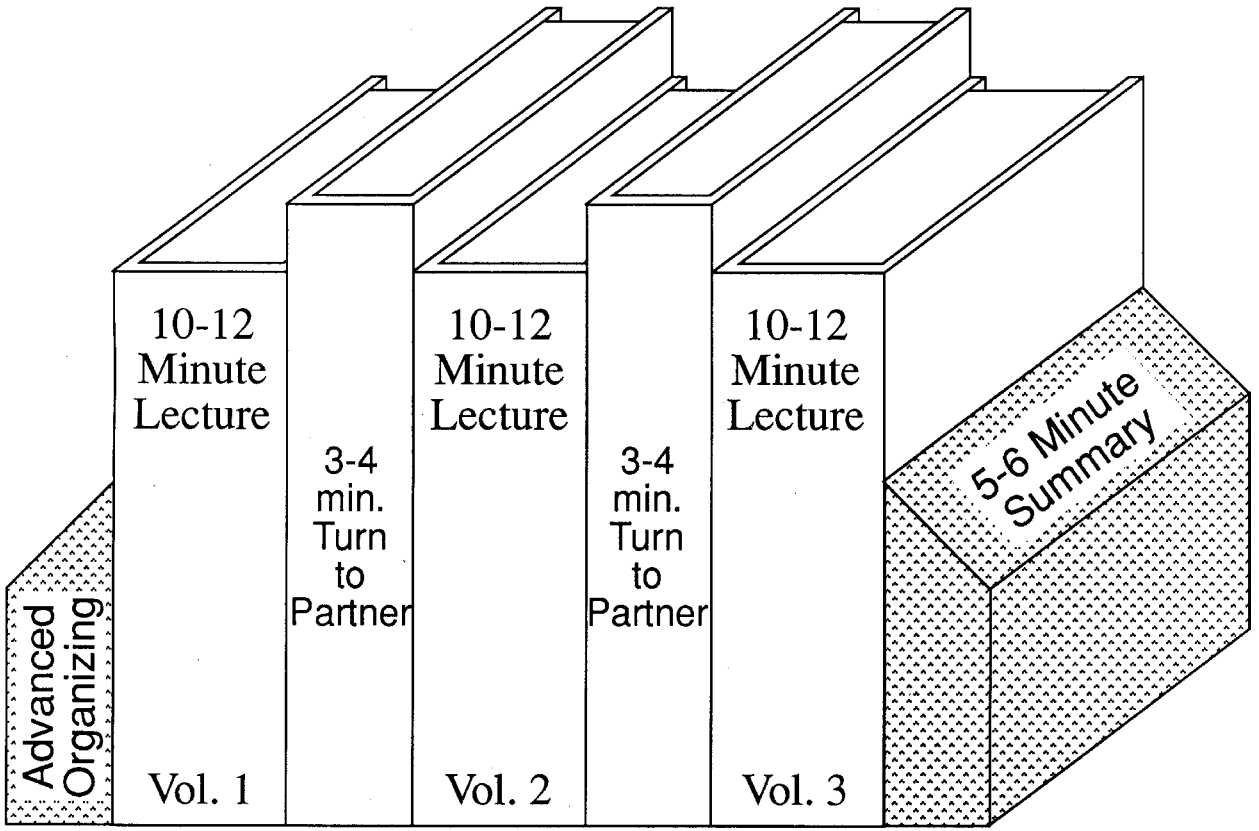
- Positive Interdependence
- Individual and Group Accountability
- Face-to-Face Promotive Interaction
- Teamwork Skills
- Group Processing

Cooperative Learning:

Active Learning for the College Classroom

- **Informal** Cooperative Learning Groups
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups

Informal Cooperative Learning and The Lecture



LF

Advance Organizer

"The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly."

David Ausubel - *Educational psychology: A cognitive approach*, 1968.

Formulate-Share-Listen-Create

Informal Cooperative Learning Group
Introductory Pair Discussion of a

FOCUS QUESTION

1. **Formulate** your response to the question individually
2. **Share** your answer with a partner
3. **Listen** carefully to your partner's answer
4. Work together to **Create** a new answer through discussion

Formulate-Share-Listen-Create

Informal Cooperative Learning Group
Introductory Pair Discussion of an

Active/Cooperative Learning Success Story

1. **Formulate** your response to the question individually
2. **Share** your answer with a partner
3. **Listen** carefully to your partner's answer
4. Work together to **Create** a new answer through discussion

Informal CL (Book Ends on a Lecture) with Concept Tests

Physics

Peer Instruction

Eric Mazur - Harvard – http://galileo.harvard.edu

Peer Instruction www.prenhall.com

Richard Hake (Interactive engagement vs traditional methods) http://carini.physics.indiana.edu/SDI/

Chemistry

Chemistry ConcepTests

Art Ellis - UW Madison – www.chem.wisc.edu/~concept

ModularChem Consortium – http://mc2.cchem.berkeley.edu/

Thinking Together video

Derek Bok Center – www.fas.harvard.edu/~bok_cen/

Hake http://carini.physics.indiana.edu/SDI/

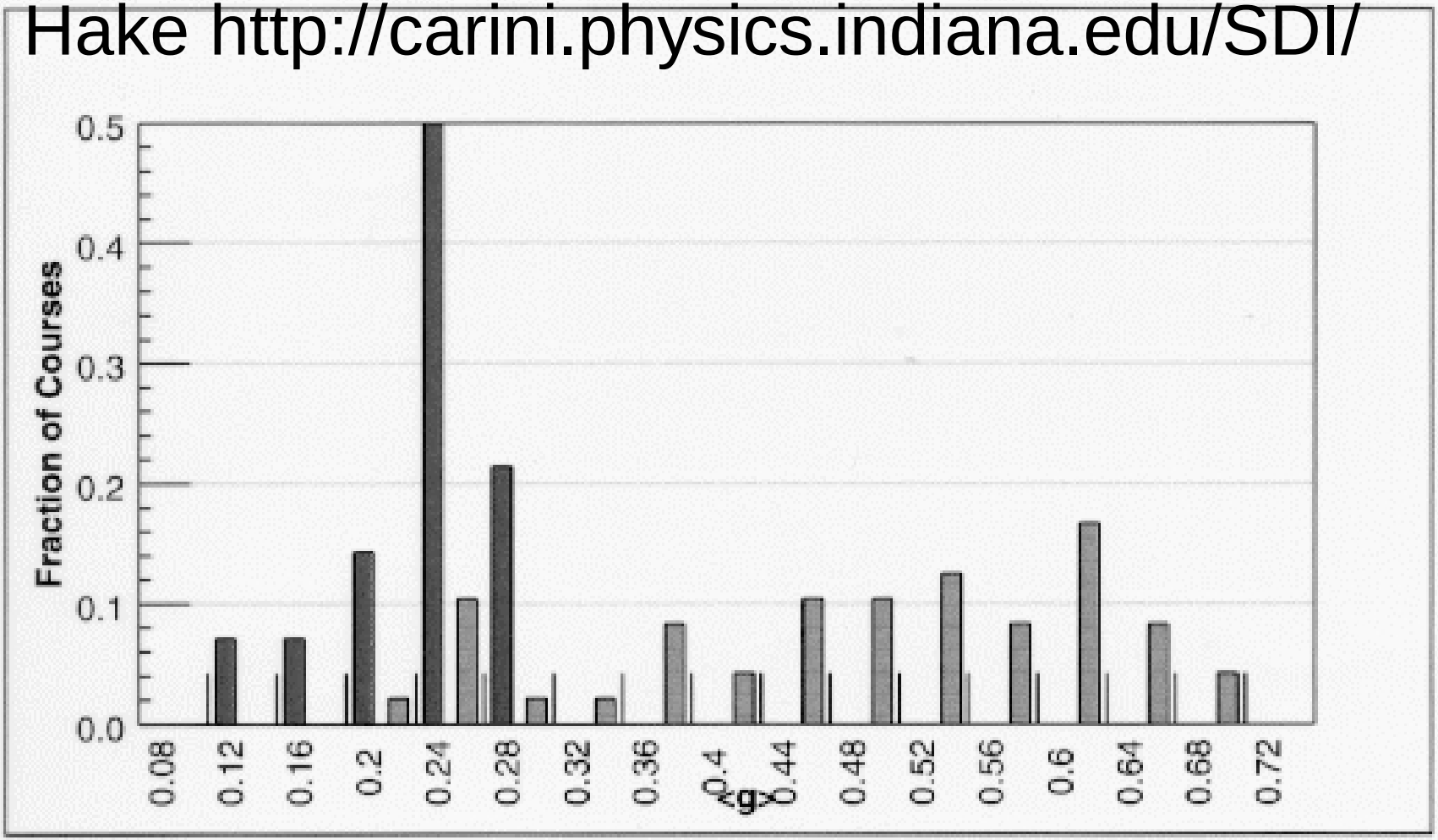


Fig. 2. Histogram of the average normalized gain <g>: dark (red) bars show the *fraction* of 14 traditional courses (N = 2084), and light (green) bars show the *fraction* of 48 interactive engagement courses (N = 4458), both within bins of width $\delta\langle g\rangle = 0.04$ centered on the <g> values shown.

III. CONCEPTUAL TEST RESULTS

A. Gain vs Pretest Graph - All Data

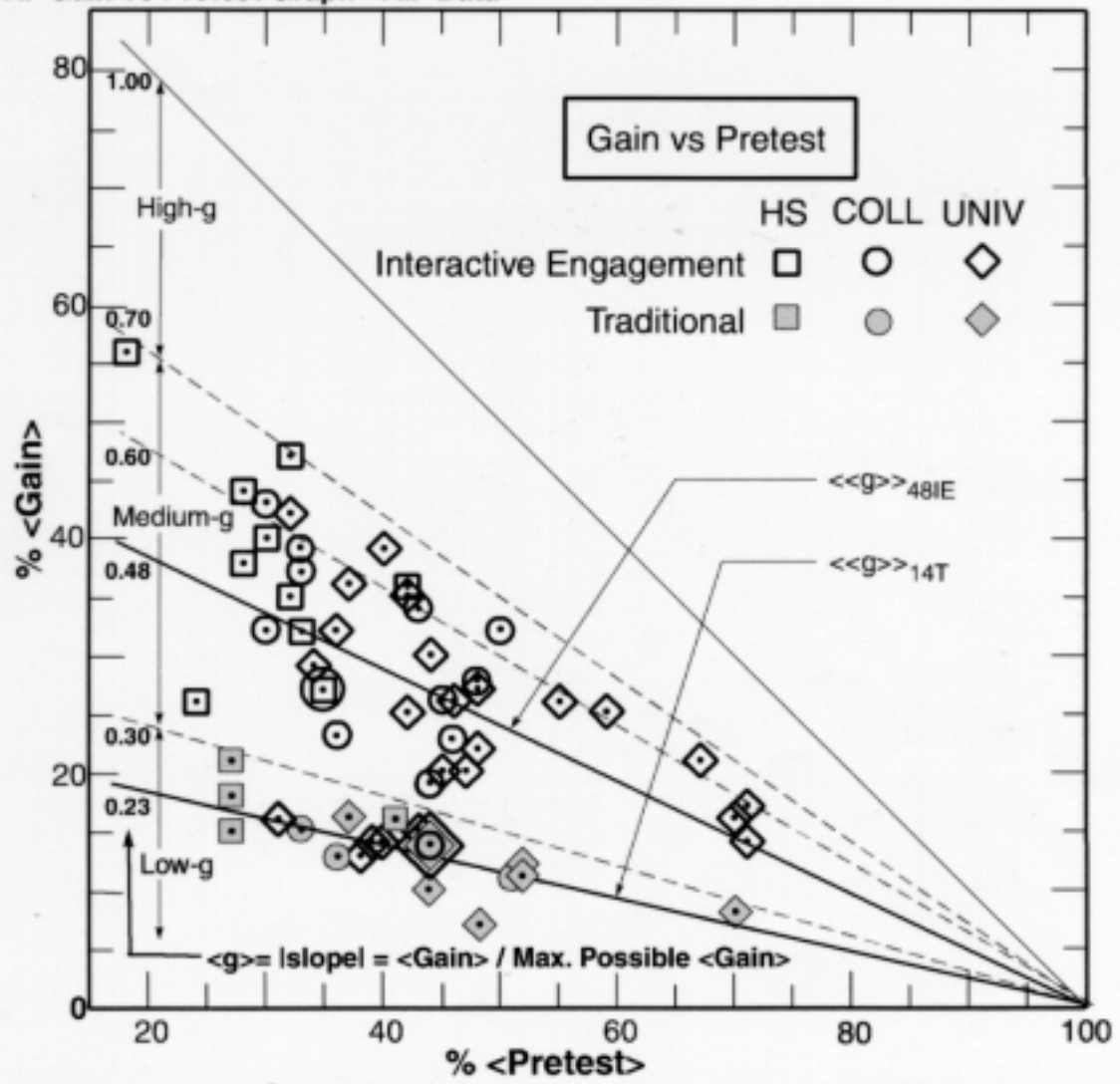


Fig. 1. %<Gain> vs %<Pretest> score on the conceptual Mechanics Diagnostic (MD) or Force Concept Inventory (FCI) tests for 62 courses enrolling a total N = 6542 students: 14 traditional (T) courses (N = 2084) which made little or no use of interactive engagement (IE) methods, and 48 IE courses (N = 4458) which made considerable use of IE methods. Slope lines for the average of the 14 T courses $\langle\langle g \rangle\rangle_{14T}$ and 48 IE courses $\langle\langle g \rangle\rangle_{48IE}$ are shown, as explained in the text.

Informal Cooperative Learning Groups

Can be used at any time

Can be short term and ad hoc

May be used to break up a long lecture

Provides an opportunity for students to process material they have been listening to

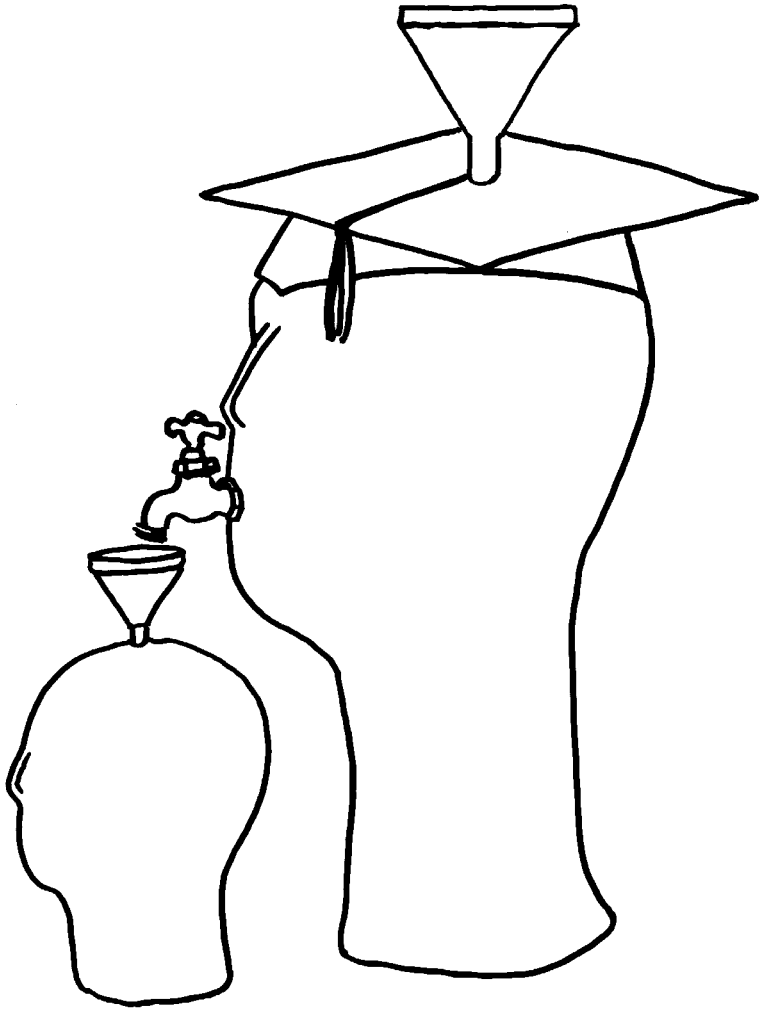
Are especially effective in large lectures

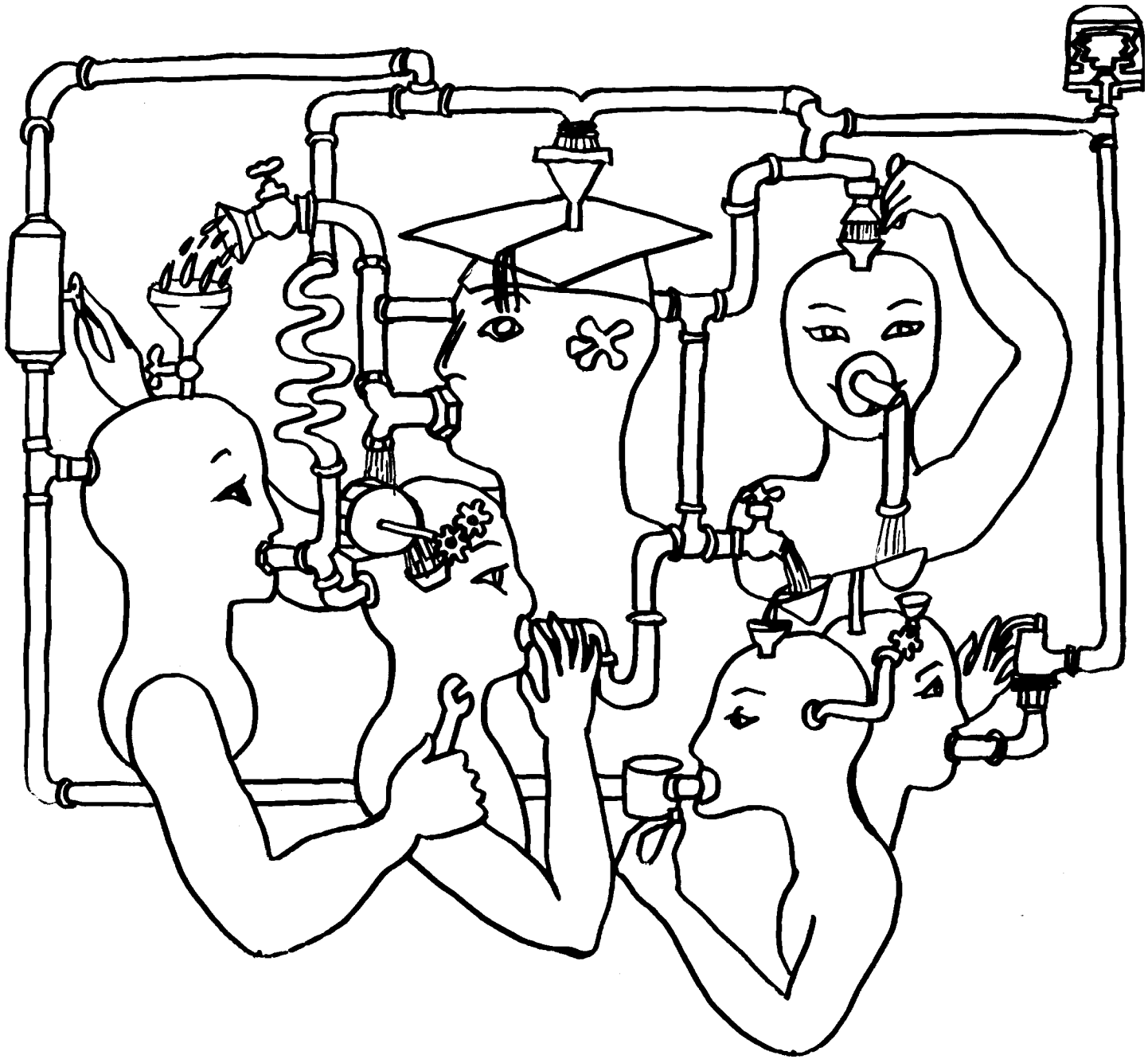
Include "book ends" procedure

Are not as effective as Formal Cooperative Learning or Cooperative Base Groups

Changes in the Paradigm

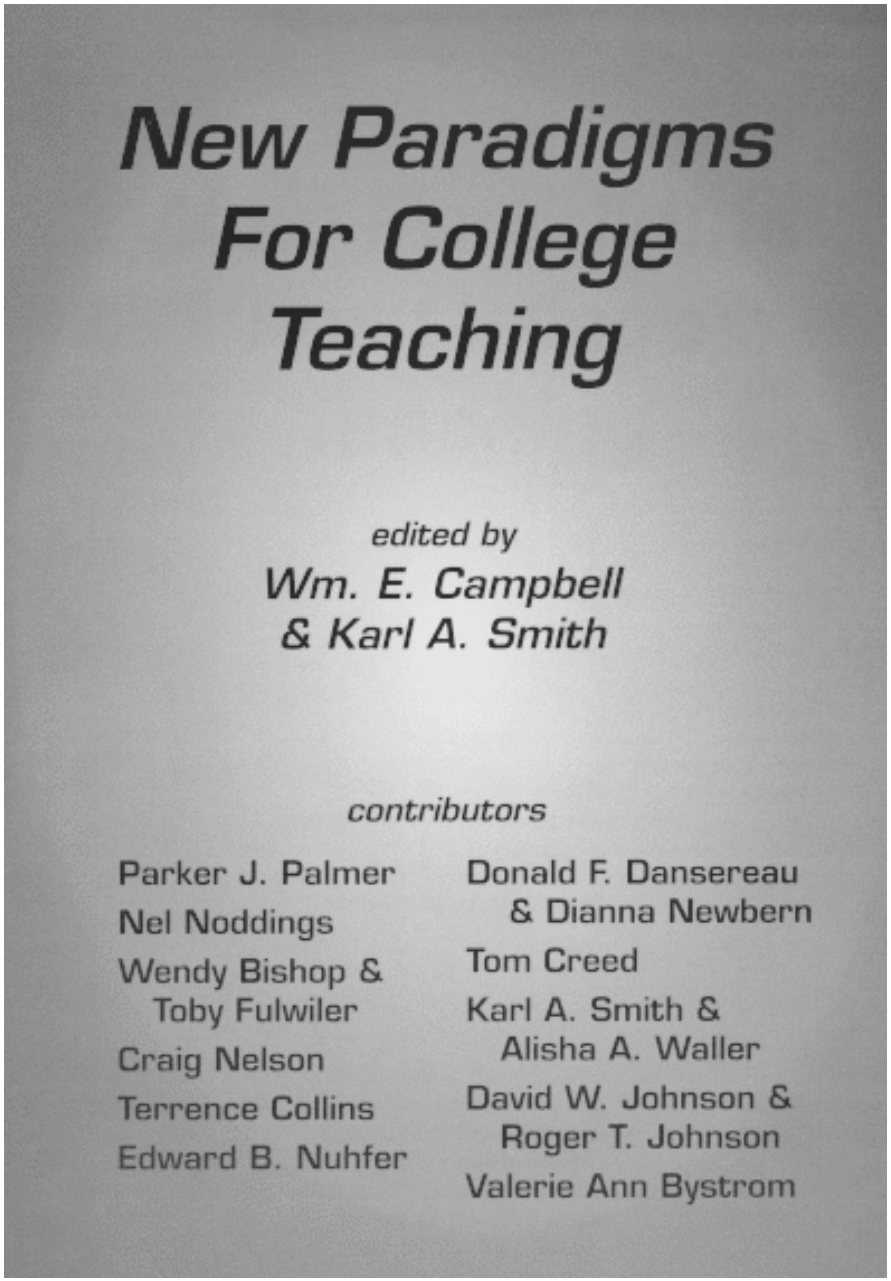
- What changes have you noticed?
- What changes would you like to see?
- What are the pressures for change?
- What are the necessary conditions for change?





Robert Barr & John Tagg. From teaching to learning: A new paradigm for undergraduate education. *Change, 27*(6), 1995.

Wm. Campbell & Karl Smith. *New Paradigms for College Teaching*. Interaction Books, 1997.



Comparison of Old and New Paradigms for College Teaching

	Old Paradigm	New Paradigm
Knowledge	Transferred from Faculty to Students	Jointly Constructed by Students and Faculty
Students	Passive Vessel to be Filled by Faculty's Knowledge	Active Constructor, Discoverer, Transformer of Knowledge
Mode of Learning	Memorizing	Relating
Faculty Purpose	Classify and Sort Students	Develop Students' Competencies and Talents
Student Goals	Students Strive to Complete Requirements, Achieve Certification within a Discipline	Students Strive to Grow, Focus on Continual Lifelong Learning within a Broader System
Relationships	Impersonal Relationship Among Students and Between Faculty and Students	Personal Transaction Among Students and Between Faculty and Students
Context	Competitive/Individualistic	Cooperative Learning in Classroom and Cooperative Teams Among Faculty
Climate	Conformity/Cultural Uniformity	Diversity and Personal Esteem/ Cultural Diversity and Commonality
Power	Faculty Holds and Exercises Power, Authority, and Control	Students are Empowered; Power is Shared Among Students and Between Students and Faculty
Assessment	Norm-Referenced (i.e., Graded "On the Curve"); Typically Multiple Choice Items; Student rating of instruction at end of course	Criterion-Referenced; Typically Performances and Portfolios; Continual Assessment of Instruction
Ways of Knowing	Logico-Scientific	Narrative
Epistemology	Reductionist; Facts and Memorization	Constructivist; Inquiry and Invention
Technology Use	Drill and Practice; Textbook Substitute; Chalk and Talk Substitute	Problem Solving, Communication, Collaboration, Information Access, Expression
Teaching Assumption	Any Expert can Teach	Teaching is Complex and Requires Considerable Training

New Paradigm

- Defining educational objectives, facilitating development of critical and creative thinking and problem-solving skills
- Active learning (individual and group activities in class)
- Structured cooperative learning (including multidisciplinary teamwork and facilitating development of written and oral communication skills)
- Writing and (multidisciplinary) design across the curriculum
- Inquiry and discovery learning (problem-based, case-based)
- Teaching to diversity (different learning styles, ethnicities, genders)
- Appropriate use of technology (tools, simulation, exploration)

Pressures to Change

- National Science Foundation
- Professional Accreditation
- Financial
- Employers
- University Administration
- Boyer Commission
- Educational Research

Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology

Goal – *All students have access to supportive, excellent undergraduate education in science, mathematics, engineering, and technology, and all students learn these subjects by direct experience with the methods and processes of inquiry.*

Recommend that *SME&T faculty:* Believe and affirm that every student can learn, and model good practices that increase learning; starting with the student's experience, but have high expectations within a supportive climate; and build inquiry, a sense of wonder and the excitement of discovery, plus communication and teamwork, critical thinking, and life-long learning skills into learning experiences.

Welcome to

ABET

Accreditation Board for
Engineering and
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Submit comments and
recommendations about
this site to:
Webmaster@abet.org

Criterion 3. Program Outcomes and Assessment

Engineering programs must demonstrate that their graduates have

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Business Week
December 22, 1997

EDUCATION

THE NEW U

A tough market is reshaping colleges

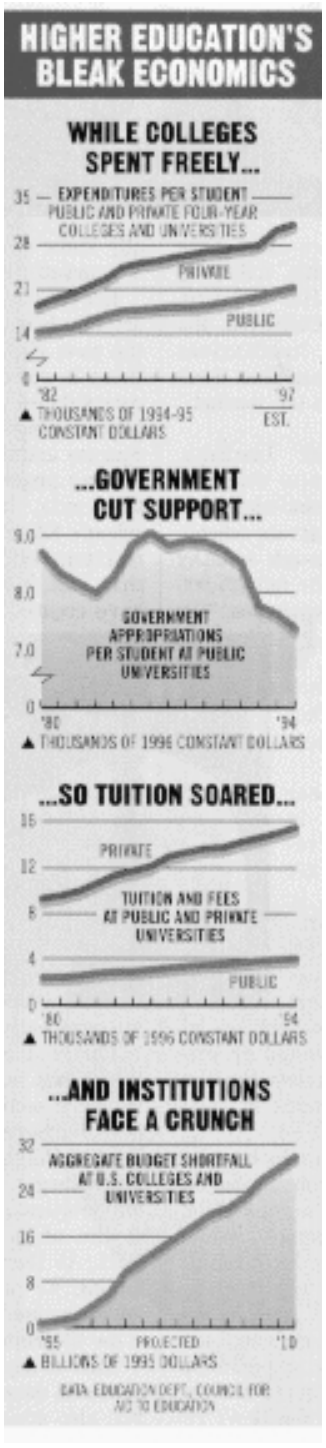
On an autumn afternoon on the manicured grounds of the red-brick University of Florida at Gainesville, students stroll under palms and moss-draped oaks. It's a classic collegiate tableau—and completely at odds with the radical vision of the man who presides over the campus from a modest second-story office. It's not that John V. Lombardi wants to destroy what he sees. Quite simply, he has to.

As president of the huge state institution, Lombardi contends with a legislature that won't let him raise tuition but has cut university appropriations by 15% since 1991. In response, "we have taken the great leap forward and said: 'Let's pretend we're a corporation,'" Lombardi says. Defying traditional academic notions, departments now vie openly for resources. English professors must demonstrate, in essence, that Chaucer pays the bills using funds as effectively as engineering or business classes. Departments that meet quality and productivity criteria win shares of $2 million in discretionary funding.

This isn't a universally popular strategy. Some professors and administrators fear the effects of the new strictures on academic quality. Many hope it is just a president's passing fancy. "Things like this come and go all the time," says John Kraft, dean of the University of Florida's College of Business Administration. Lombardi understands the dissension and skepticism. At institutions like his, he says, "everyone assumes that we'll just keep churning the paper, and it will be business as usual."

It isn't—at Florida or at other colleges and universities across the nation. Behind ivied walls and on leafy quadrangles, administrators and professors acknowledge this new reality. Higher education is changing profoundly, retreating from the ideals of liberal arts and the leading-edge research it always has cherished. Instead, it is behaving more like the $250 billion business it has become.

DISCIPLINE. Universities are rethinking the big lecture halls, faculty tenure, discrete academic departments, and other features that have defined traditional institutions for a century. They are designing curriculums more relevant to employers, communities, and students. Schools are pursuing fiscal discipline, forcing accountability on organizations that for decades have expanded as they pleased. And they're wiring the ivory towers, creating with technology more efficient mediums of instruction.



Reinventing Undergraduate Education: A Blueprint for America's Research Universities

The Boyer Commission on Educating Undergraduates in the Research Universities, April 1998

Ten Ways to Change Undergraduate Education

Make Research-Based Learning the Standard
Construct an Inquiry-Based Freshman Year
Build on the Freshman Foundation
Remove Barriers to Interdisciplinary Education
Link Communications Skills and Course Work
Use Information Technology Creatively
Culminate with a Capstone Experience
Educate Graduate Students as Apprentice Teachers
Change Faculty Reward Systems
Cultivate a Sense of Community

http://notes/cc.sunysb.edu/Pres/boyer.nsf

Formulate-Share-Listen-Create

Informal Cooperative Learning Group
Closing Pair Generation of

QUESTIONS/COMMENTS?

1. **Formulate** your questions/comments individually
2. **Share** with a neighbor
3. **Listen** carefully to your neighbor's answer
4. **Create** at least one question/comment

Session Summary
(Minute Paper)

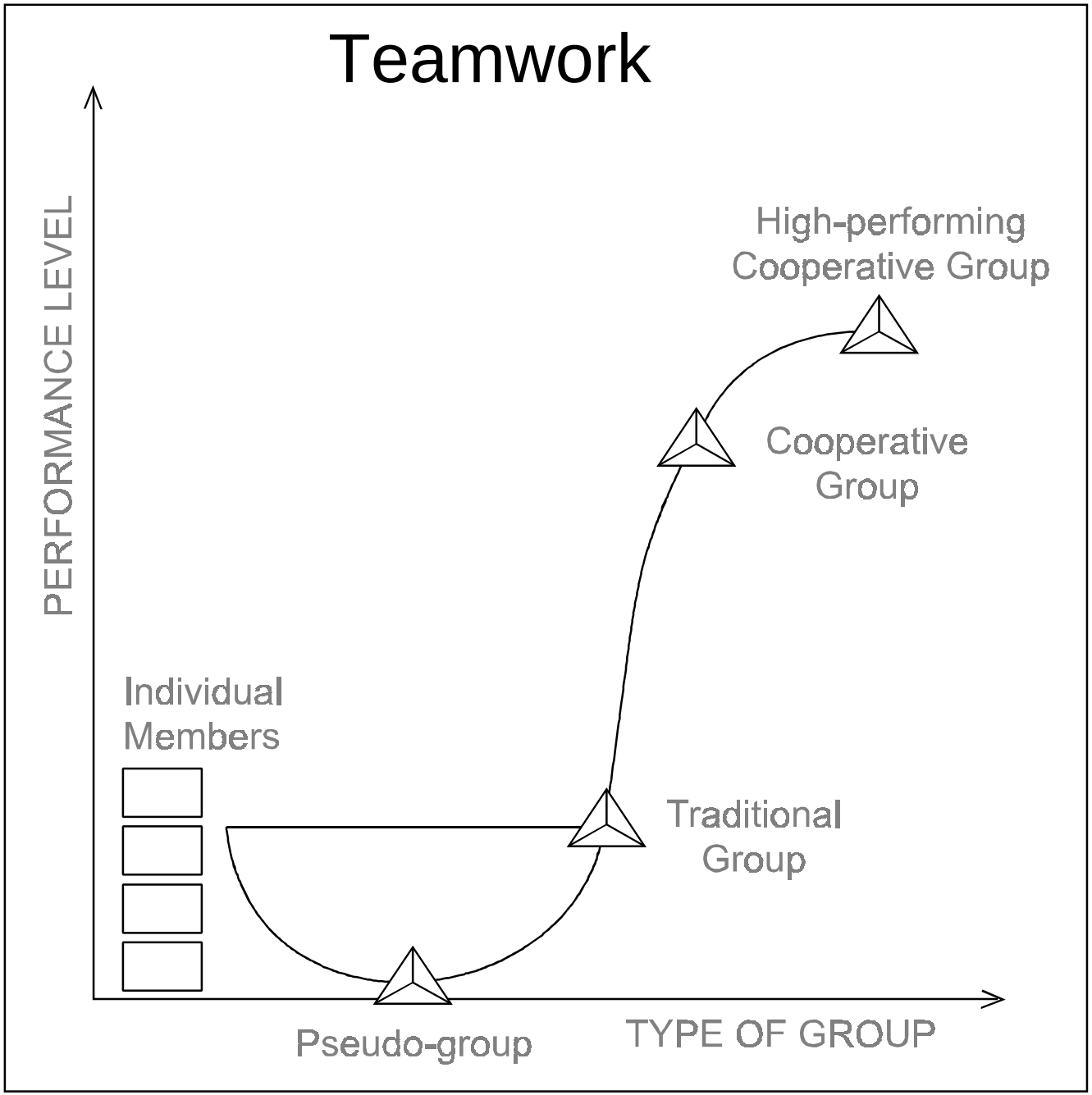
Reflect on the session:

1. What were the most important points for you?
2. What is one thing you would be willing to try?
3. What questions do you have?

Discuss with a partner:

1. Points that were useful, meaningful, interesting, applicable, etc.
2. Questions that you have.

Formal Cooperative Learning Task Groups


Teamwork
PERFORMANCE LEVEL
High-performing
Cooperative Group
Cooperative
Group
Individual
Members
Traditional
Group
Pseudo-group
TYPE OF GROUP

A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable

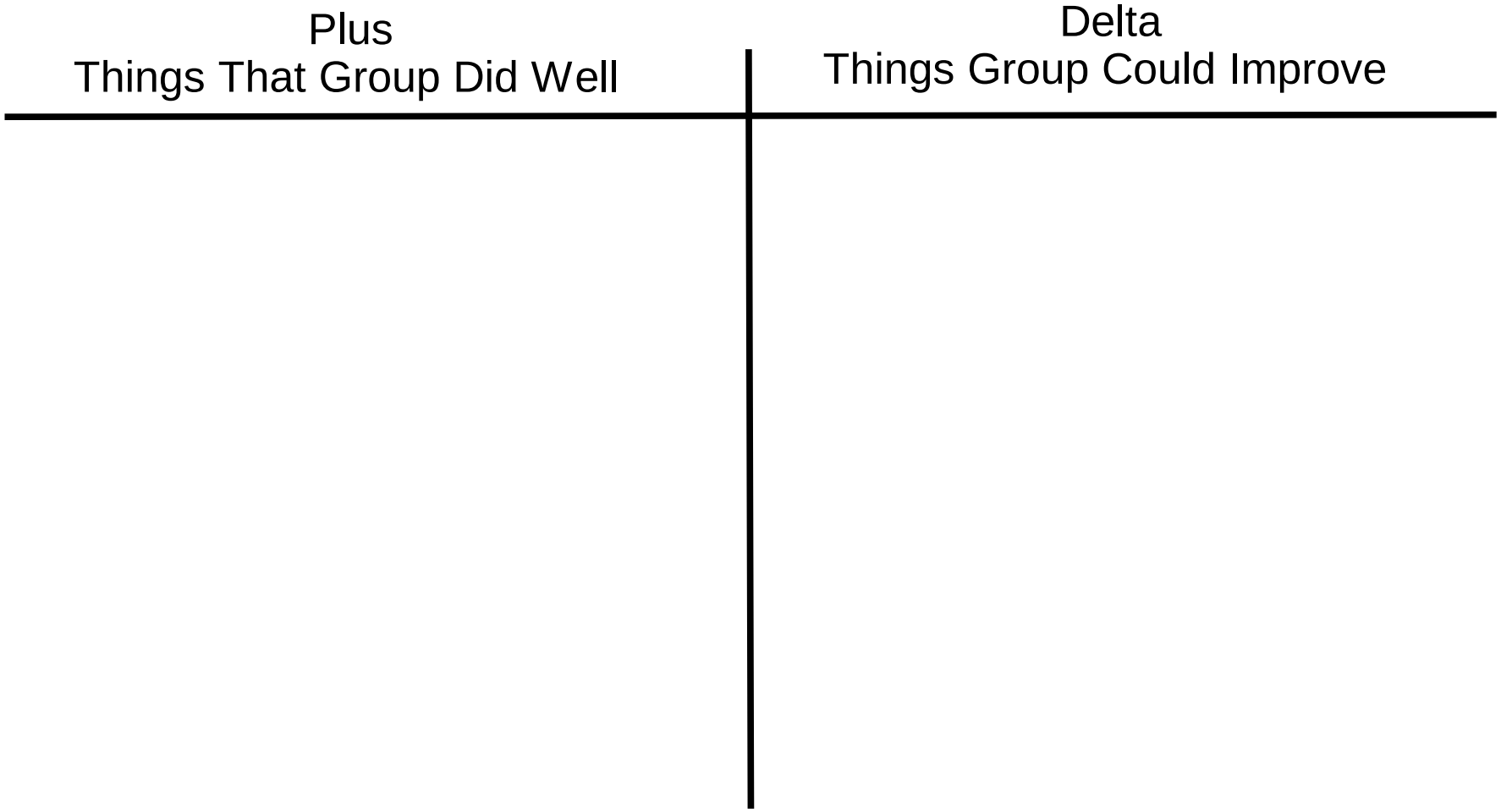
- SMALL NUMBER
- COMPLEMENTARY SKILLS
- COMMON PURPOSE & PERFORMANCE GOALS
- COMMON APPROACH
- MUTUAL ACCOUNTABILITY

--Katzenbach & Smith
The Wisdom of Teams

Group Task and Maintenance Roles

Group Task Roles	Group Maintenance Roles
Initiating	Encouraging
Seeking Information	Expressing Feelings
Giving Information	Harmonizing
Seeking Opinions	Compromising
Giving Opinions	Facilitating Communications
Clarifying	Setting Standards or Goals
Elaborating	Testing Agreement
Summarizing	Following

Group Processing
– Plus/Delta Format –



Cooperative Learning is instruction that involves people working in teams to accomplish a common goal, under conditions that involve both *positive interdependence* (all members must cooperate to complete the task) and *individual and group accountability* (each member is accountable for the complete final outcome).

Key Concepts

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

Formal Cooperative Learning

1. Jigsaw Groups
2. Peer Composition or Editing Groups
3. Comprehension Groups
4. Problem Solving, Project, or Presentation Groups
5. Review/Correct Homework
6. Constructive Academic Controversy
7. Group Tests

Professor's Role in Formal Cooperative Learning

1. Specifying Objectives

2. Making Decisions

3. Explaining Task, Positive Interdependence, and Individual Accountability

4. Monitoring and Intervening to Teach Skills

5. Evaluating Students' Achievement and Group Effectiveness

Problem Based Cooperative Learning Format

TASK: Solve the problem(s) or Complete the project.

INDIVIDUAL: Estimate answer. Note strategy.

COOPERATIVE: One set of answers from the group, strive for agreement, make sure everyone is able to explain the strategies used to solve each problem.

EXPECTED CRITERIA FOR SUCCESS: Everyone must be able to explain the strategies used to solve each problem.

EVALUATION: Best answer within available resources or constraints.

INDIVIDUAL ACCOUNTABILITY: One member from your group may be randomly chosen to explain (a) the answer and (b) how to solve each problem.

EXPECTED BEHAVIORS: Active participating, checking, encouraging, and elaborating by all members.

INTERGROUP COOPERATION: Whenever it is helpful, check procedures, answers, and strategies with another group.

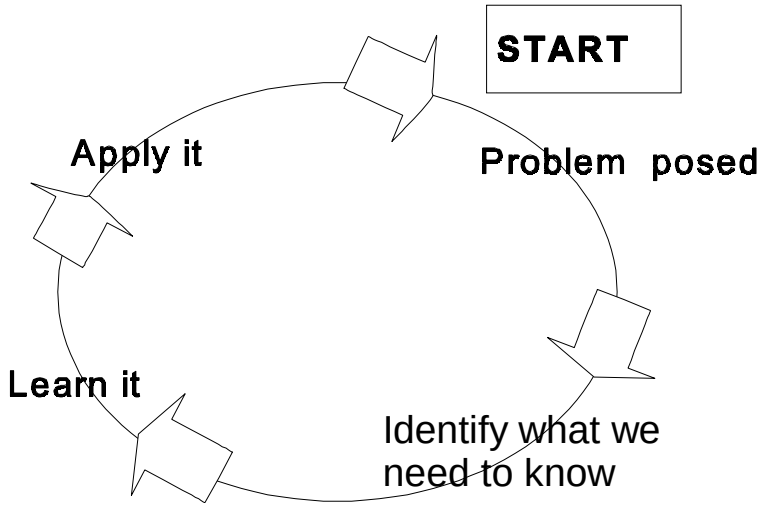
Problem-Based Learning PBL

Problem-based learning is the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered *first* in the learning process – Barrows and Tamlyn, 1980

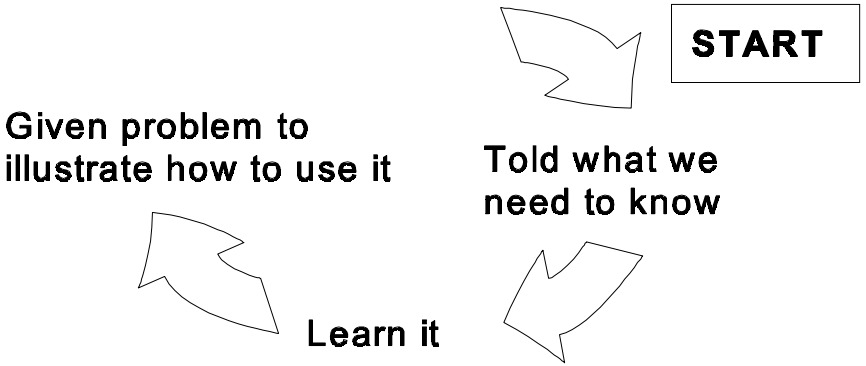
Core Features of PBL

- Learning is student-centered
- Learning occurs in small student groups
- Teachers are facilitators or guides
- Problems are the organizing focus and stimulus for learning
- Problems are the vehicle for the development of clinical problem-solving skills
- New information is acquired through self-directed learning

Problem-Based Learning



Subject-Based Learning



Normative Professional Curriculum:

1. Teach the relevant basic science,

2. Teach the relevant applied science, and

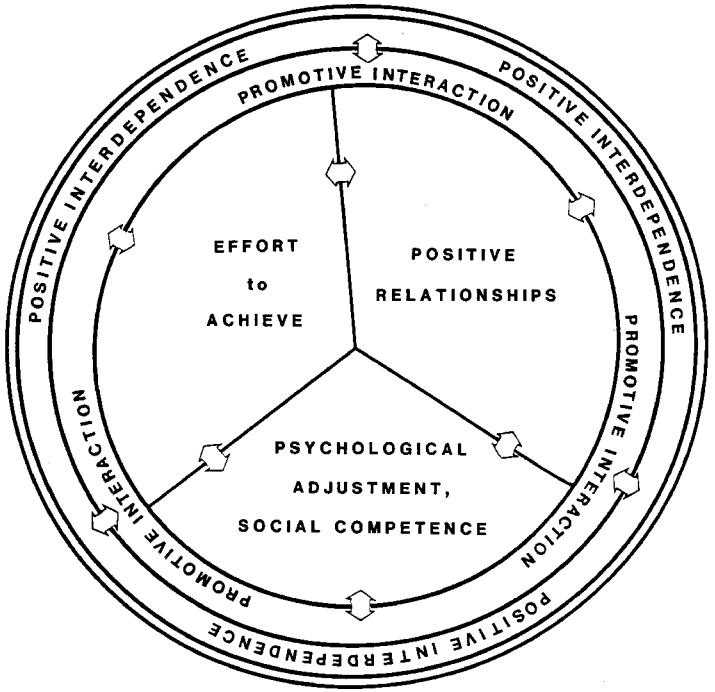
3. Allow for a practicum to connect the science to actual practice.

Cooperative Learning Research Rationale

- Over 500 Experimental and 100 Correlational Studies
- First study conducted in 1897
- 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



Cooperative Learning: Meta-analysis

Springer, L., Stanne, M. E., & Donovan, S. 1999. Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research* , *69*(10), 21-51.

Literature search on studies of small-group (predominantly cooperative) learning in postsecondary science, mathematics, engineering, and technology (SMET) produced 383 reports from 1980 or later, 39 of which met the rigorous inclusion criteria for meta-analysis. The main effect of small-group learning on achievement, persistence, and attitudes among undergraduates in SMET was significant and positive. **Mean effect sizes for achievement, persistence, and attitudes were 0.51, 0.46, and 0.55, respectively. "The 0.51 effect of small-group learning on achievement reported in this study would move a student from the 50 th percentile to the 70 th on a standardized test. Similarly, a 0.46 effect on students' persistence is enough to reduce attrition in SMET courses and programs by 22%."**

The Harvard Assessment Seminars

Richard J. Light

All the specific findings point to, and illustrate, one main idea. It is that students who get the most out of college, who grow the most academically, and who are the happiest, organize their time to include interpersonal activities with faculty members, or with fellow students, built around substantive, academic work.

Environmental Factors That Enhance Students' Academic and Personal Development and Satisfaction

Alexander Astin in *What matters in college: Four critical years revisited. Jossey-Bass, 1993.*

Student-student interaction
Student-faculty interaction

A faculty that is very student-oriented
Discussing racial/ethnic issues with other students
Hours devoted to studying
Tutoring other students
Socializing with students of different race/ethnicity
A student body that has high socioeconomic status
An institutional emphasis on diversity
A faculty that is positive about the general education program
A student body that values altruism and social activism

Cooperative Base Groups
For Personal and Academic Support

Cooperative Base Groups

Are Heterogeneous

Are Long Term (at least one quarter or semester)

Are Small (3-5 members)

Are for support

May meet at the beginning of each session or may meet between sessions

Review for quizzes, tests, etc. together

Share resources, references, etc. for individual projects

Provide a means for covering for absentees

Key Features of Cooperative Learning

Active/Interactive
Cooperative
Personal (before professional)
Structure (before task)
Knee-to-Knee, Eye-to-Eye/Space/Focus
Challenging task (worthy of group effort)
Students talking through the material (cognitive rehearsal)
Learning groups are small (2-5) and assigned
Heterogeneous
Your own cooperative group

Good teaching comes from the identity and integrity of the teacher. . .Good teachers possess a capacity for connectedness.

Parker J. Palmer in *The courage to teach: Exploring the inner landscape of a teacher's* life. Jossey-Bass, 1998.

The biggest and most long-lasting reforms of undergraduate education will come when individual faculty or small groups of instructors adopt the view of themselves as reformers within their immediate sphere of influence, the classes they teach every day.

K. Patricia Cross