Cooperative Inquiry

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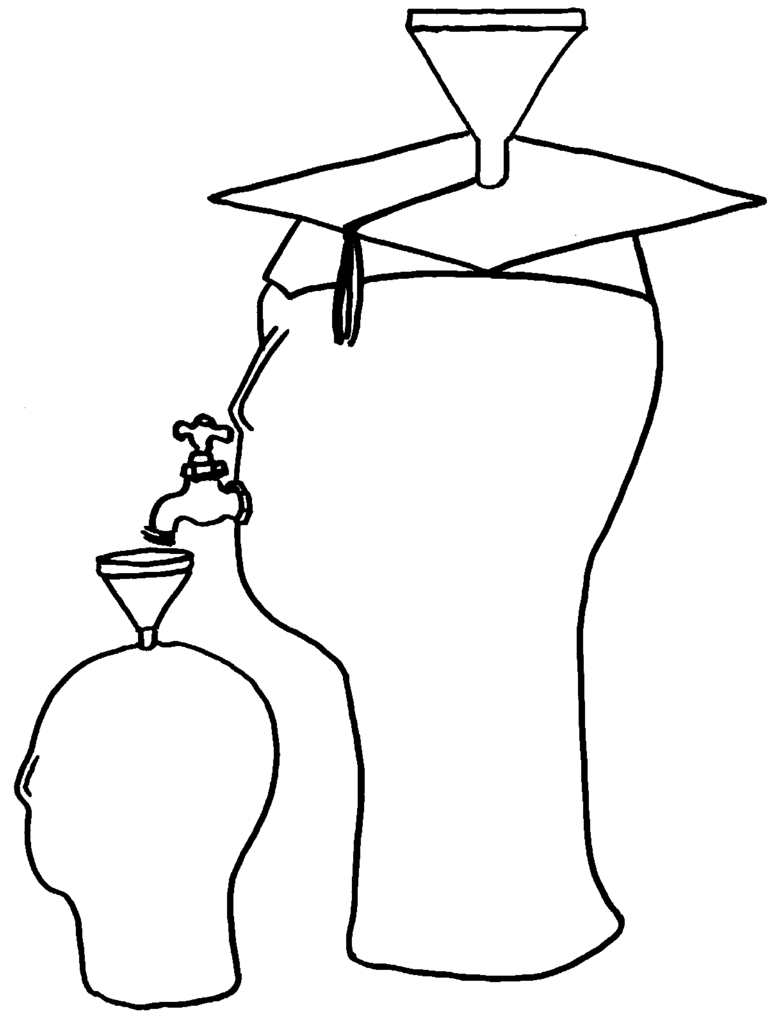
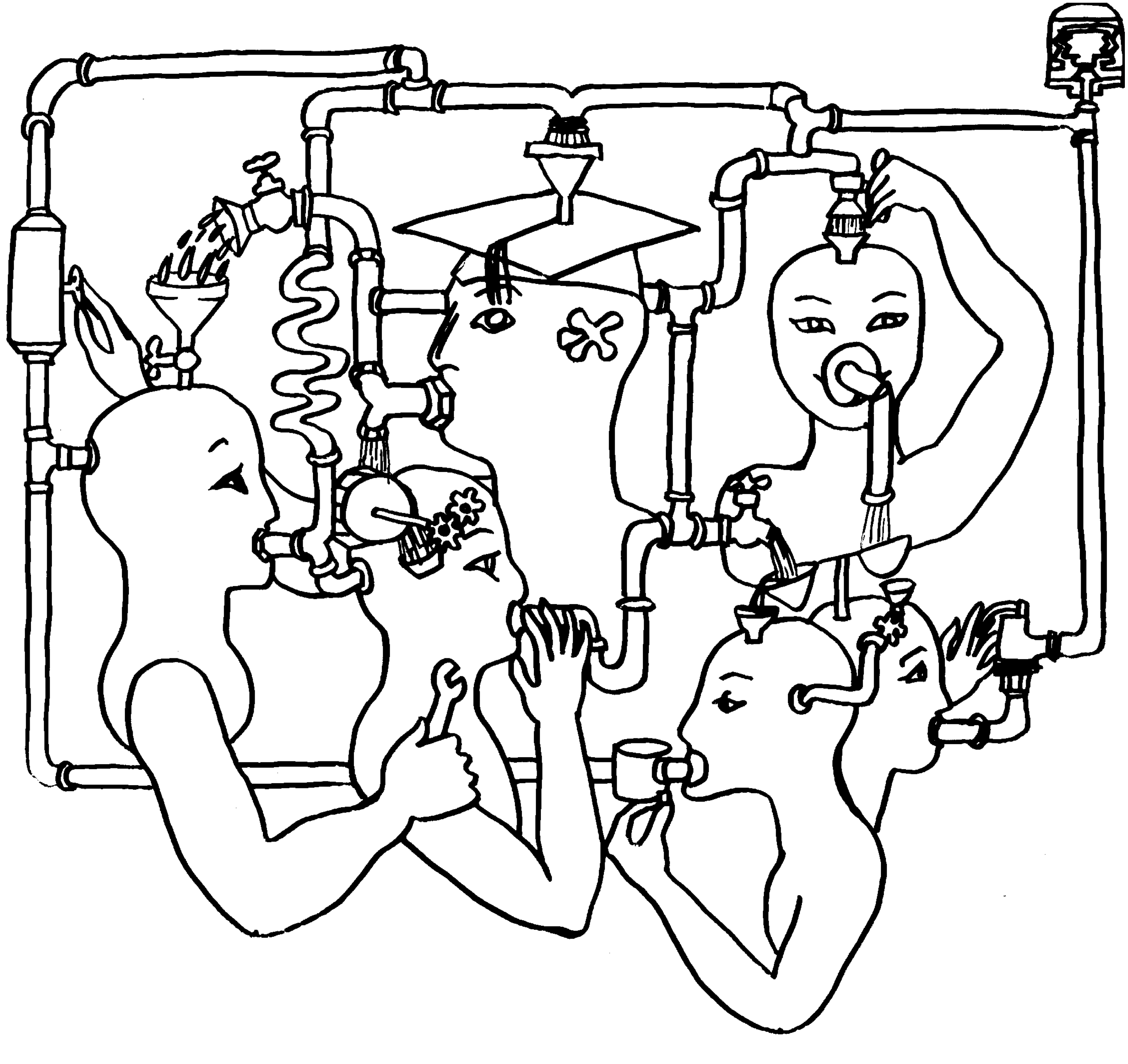
Why Cooperative Inquiry?
What are The Forces Driving These Changes?

What is the Current Status of Cooperative Inquiry?

What are Some Approaches for Designing These Experiences & Courses?





Some Forces Driving These Changes

- NSF - Career Development Award & Shaping the Future
- ABET
  - Assessment
  - Synthesis & Design
- Employers
- University Administration
- Boyer Commissions - Educating Undergraduates in the Research Universities &Scholarship Reconsidered
- Educational Research
  - Active, Interactive & Cooperative Learning
  - Inquiry & Problem-Based Learning

Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology 1996 Report to the NSF

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.*

<u>Institutions of Higher Education</u>

We 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.

! *SME&T departments*: Set departmental goals and accept responsibility for undergraduate learning, with measurable expectations for all students, offer a curriculum engaging the broadest spectrum of students; use technology effectively. . .

Accreditation Board for Engineering and Technology
Engineering Criteria 2000

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.

Employer's Checklist — Boeing Company

! A good grasp of these engineering fundamentals:
 Mathematics (including statistics)
 Physical and life sciences
 Information technology
! A good understanding of the design and manufacturing process (i.e., an understanding of engineering)
! A basic understanding of the context in which engineering is practiced, including:
 Economics and business practice
 History
 The environment
 Customer and societal needs
! A multidisciplinary systems perspective
! Good communication skills
 Written
 Verbal
 Graphic
 Listening
! High ethical standards
! An ability to think critically and creatively as well as independently and cooperatively
! Flexibility--an ability and the self-confidence to adapt to rapid/major change
! Curiosity and a lifelong desire to learn
! A profound understanding of the importance of teamwork

Michigan State University Guiding Principles

Six Guiding Principles were established by the university in 1994 to guide MSU into the next century. We will:

- Improve Access to Quality Education and Expert Knowledge
- Achieve More Active Learning
- Generate New Knowledge and Scholarship Across the Mission
- Promote Problem Solving to Address Society's Needs
- Advance Diversity within Community
- Make People Matter

Peter McPherson, President

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

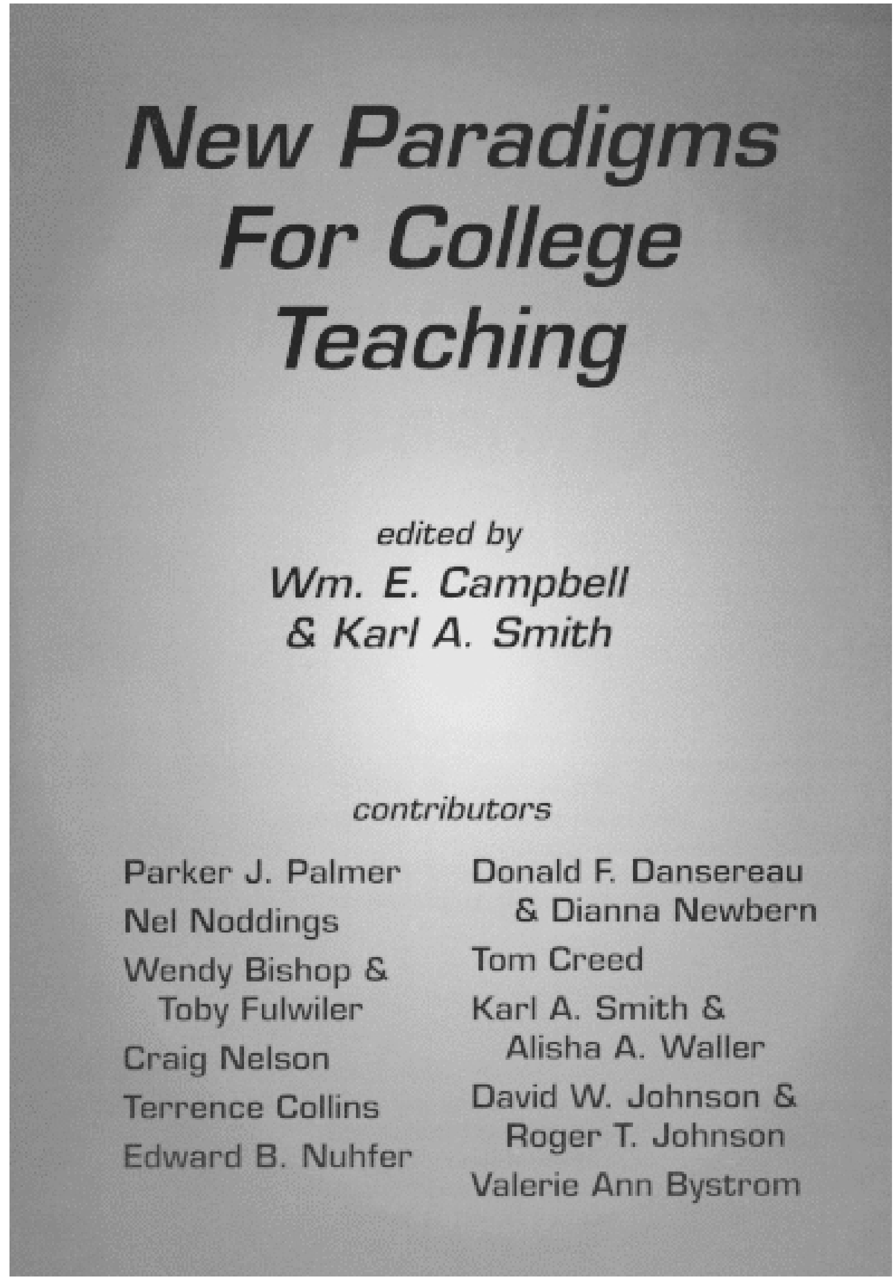
http://notes/cc.sunysb.edu/Pres/boyer.nsf

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

- Teaching to diversity (different learning styles, ethnicities, genders)
- 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)
- Appropriate use of technology (tools, simulation, exploration)

Formal Cooperative Learning
Task Groups

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.

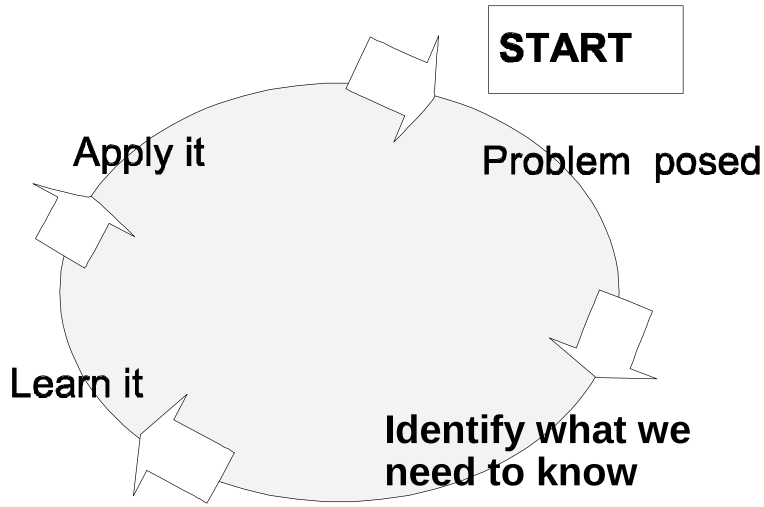
Problem-Based Learning PBL

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

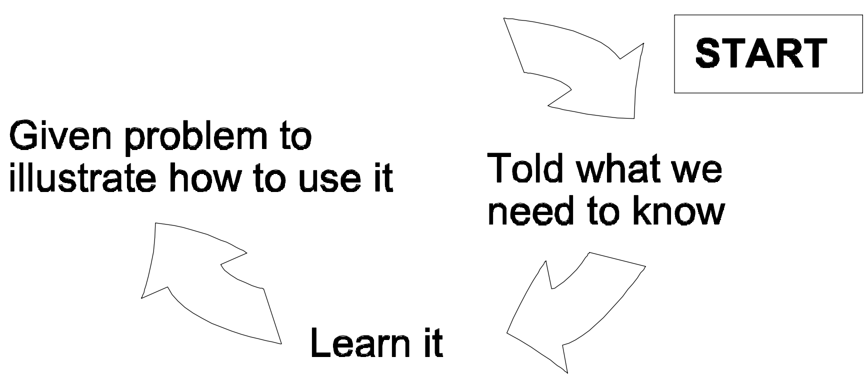
Core Features of PBL

- 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



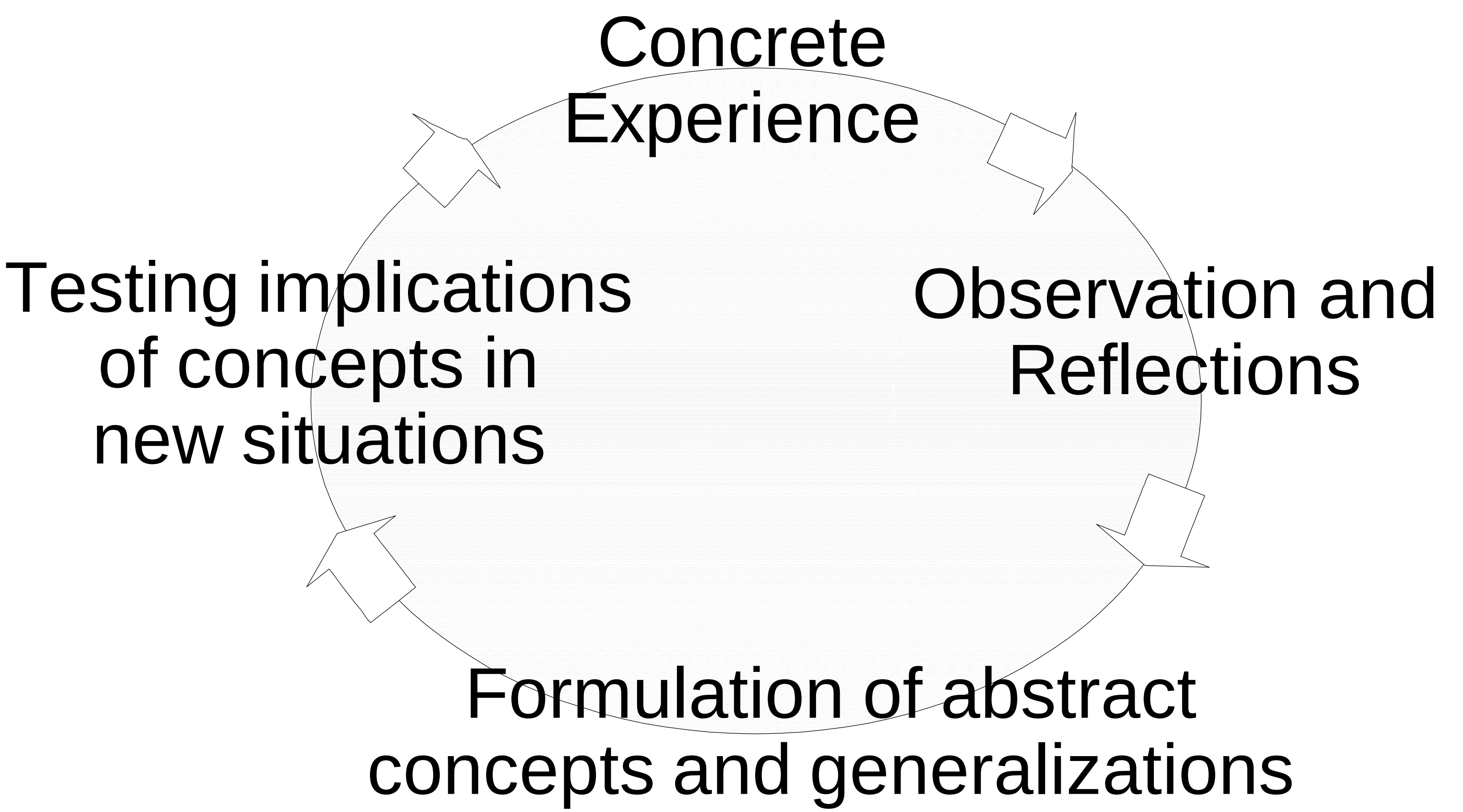
Normative Professional Curriculum:

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.

Kolb's Experiential Learning Cycle



Inquiry Learning Cycle
BSCS

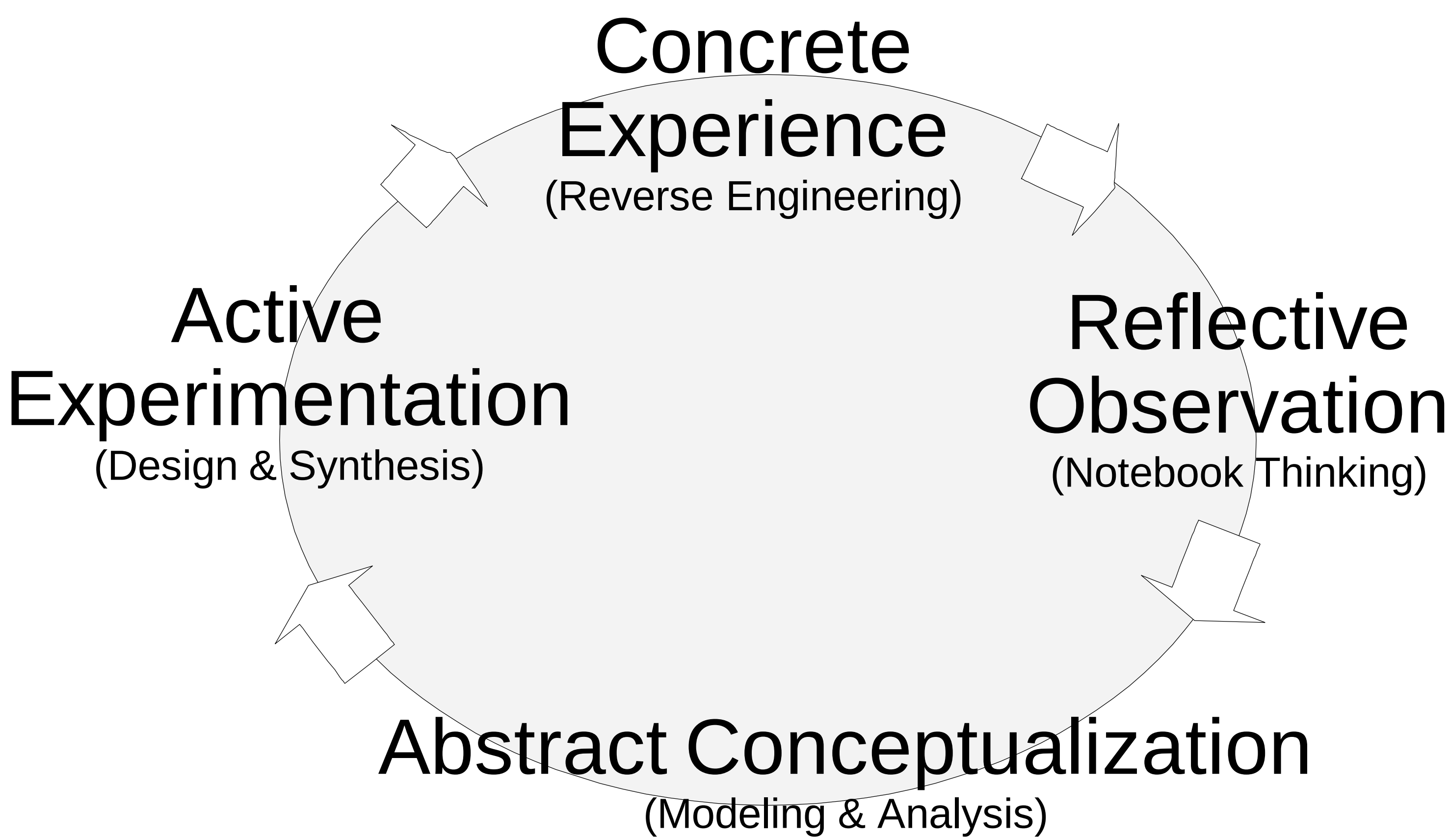
P Engage

P Explore

P Explain

P Evaluate

Product-Based Learning
Leifer (Stanford)



Leifer – Stanford

Education – A social activity that identifies a learning need, defines a teaching opportunity, and specifies a curriculum that will enable others to learn and evaluate their own performance.

Explain

What evidence will you (and your peers) accept that students have learned?

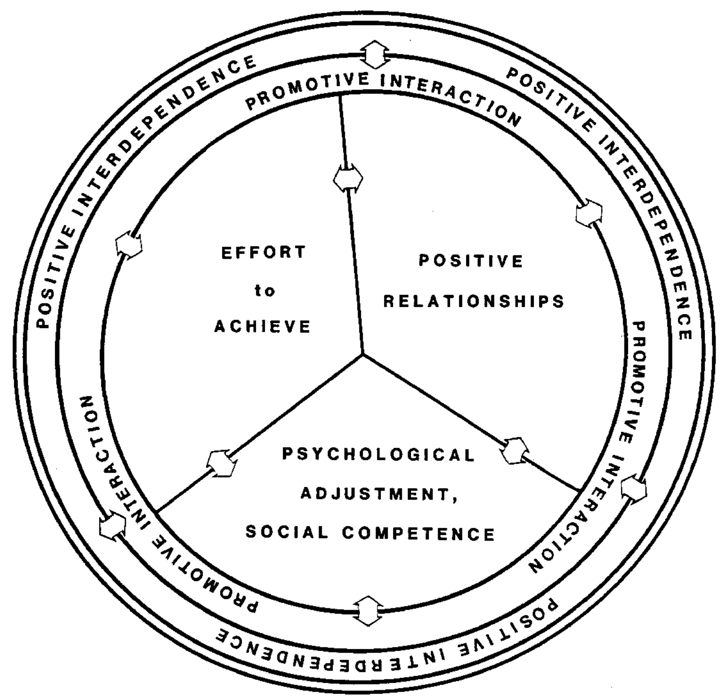
1. List individually
2. Share with others at your table
3. Prioritize

EVIDENCE
Cooperative Learning Research

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

Outcomes
(Based on meta-analysis)

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*(1), 21-52.

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 50th percentile to the 70th 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, <u>organize their time to include interpersonal activities with faculty members, or with fellow students, built around substantive, academic work.</u>

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

Growing Up Digital: The Rise of the Net Generation by Don Tapscott

The Shift From Broadcast Learning to Interactive Learning:
1. From linear to hypermedia learning
2. From instruction to construction and discovery
3. From teacher-centered to learner-centered education
4. From absorbing material to learning how to navigate and how to learn
5. From school to lifelong learning
6. From one-size-fits-all to customized learning
7. From learning as torture to learning as fun
8. From the teacher as transmitter to the teacher as facilitator

Xerox – 8 Principles for Learning by Brigitte Jordan (Xerox PARC & IRL)

1. Learning is fundamentally social
2. Cracking the whip stifles learning
3. Learning needs an environment that supports it
4. Learning crosses hierarchical bounds
5. Self-directed learning fuels the fire
6. Learning by doing is more powerful than memorizing
7. Failure to learn is often the fault of the system, not the people
8. Sometimes the best learning is unlearning

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M.E. Loverude, P.R.L. Heron, C.H. Kautz, and L.C. McDermott, "Student understanding of the first law of thermodynamics: Relating work to the adiabatic compression of an ideal gas," submitted for publication in *Phys. Educ. Res., Am.J. Phys. Suppl.* (2000). Abstract

S. Vokos, B.S. Ambrose, P.S. Shaffer, and L.C. McDermott, "Student understanding of the wave nature of matter: Diffraction and interference of particles," accepted for publication in *Phys. Educ. Res., Am.J. Phys. Suppl.* (2000). Abstract

L.C. McDermott and E.F. Redish, "Resource Letter: PER-1: Physics Education Research," *Am. J. Phys.* **67** (9) 755 (1999). (Click here for PDF version) Abstract

L.C. McDermott and L.S. DeWater, "The need for special science courses for teachers: Two perspectives," an invited chapter in *Inquiring into Inquiry Learning and Teaching in Science,* J. Minstrell and E.H. van Zee, eds., Washington, D.C.: AAAS (2000), pp. 241-257. Abstract

K. Wosilait, P.R.L. Heron., P.S. Shaffer, and L.C. McDermott, "Addressing student difficulties in applying a wave model to the interference and diffraction of light," *Phys. Educ. Res., Am. J. Phys. Supp.* **67** (7) S5 (1999). Abstract

B.S. Ambrose., Heron, P.R.L., Vokos, S., and L.C. McDermott, "Student understanding of common representations of light as an electromagnetic wave: Relating the formalism to physical phenomena," *Am. J. Phys.* **67** (10) 891 (1999). Abstract

P.R. L.Heron and L.C. McDermott, "Bridging the gap between teaching and learning in geometrical optics: The role of research," *Opt. & Phot. News* **9** (9) 30 (1998). Abstract

B.S. Ambrose, P.S. Shaffer, R.N. Steinberg, and L.C. McDermott, "An investigation of student understanding of single-slit diffraction and double-slit interference," *Am. J. Phys.* **67** (2) 146 (1999). Abstract

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M.E. Loverude, P.R.L. Heron, C.H. Kautz, and L.C. McDermott, "Student understanding of the first law of thermodynamics: Relating work to the adiabatic compression of an ideal gas," submitted for publication in Phys. Educ. Res., Am.J. Phys. Suppl.(2000).

This paper reports on an investigation of student understanding of the first law of thermodynamics. The students involved were drawn from first-year university physics courses and a second-year thermal physics course. The emphasis was on the ability of the students to relate the first law to the adiabatic compression of an ideal gas. Although all had studied the first law, few recognized its relevance. Fewer still were able to apply the concept of work to account for a change in temperature in an adiabatic process. Instead most of the students based their predictions and explanations on a misinterpretation of the ideal gas law. Even when ideas of energy and work were suggested, many students were unable to give a correct analysis. There was frequent failure to differentiate the concepts of heat, temperature, work, and internal energy. Some of the difficulties that students had in applying the concept of work in a thermal process seemed to be related to difficulties with mechanics. Findings from this study have strong implications for instruction in thermal physics and in mechanics.

L.C. McDermott and E.F. Redish, "Resource letter on Physics Education Research," Am. J. Phys. 67 (9) 755 (1999).

Excerpt from introduction: Experienced instructors recognize that in spite of their best efforts many students emerge from their study of physics with serious gaps in their understanding of important topics. In the last two decades, physicists have begun to approach this problem from a scientific erspective by conducting detailed, systematic studies on the learning and teaching of physics. These investigations have included a wide variety of populations, ranging from young children to professional physicists. The purpose of this resource letter is to provide guidance through some of the published literature on this research. The references have been selected to meet the needs of two groups of physicists engaged in physics education. The first is the growing number whose field of scholarly inquiry is (or might become) research in physics education. The second is themuch larger community of physics instructors whose primary interest is in useing the results from research as a guide for improving instruction.

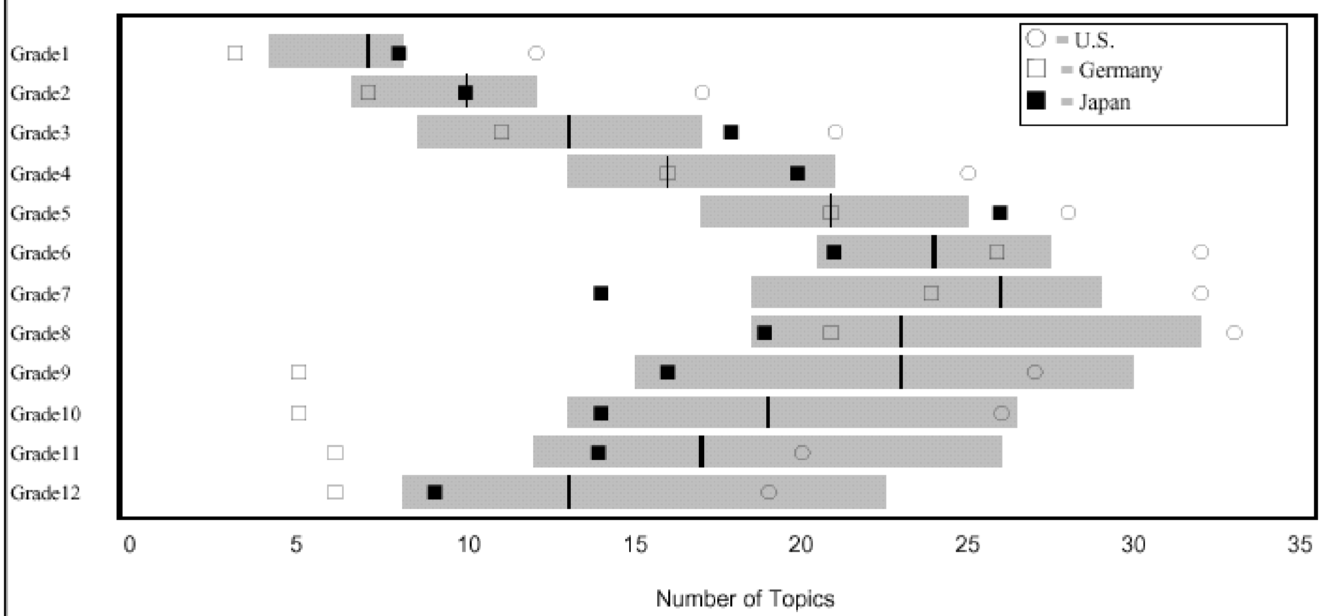
TIMSS – Third International Math and Science Study

A TIMSS Primer: Lessons and Implications for U.S. Education
by Harold W. Stevenson
http://www.edexcellence.net/library/timss.html
Implications of the Study

The reports published by the TIMSS staff hesitate to draw any firm conclusions from the study. However, analysis of its five components, and especially the case studies and video study, leads to a few possible explanations for poor U.S. performance:

- U.S. schools' fragmented, non-sequential curricula.
- The emphasis on developing rules that are automatically applied to problems rather than an understanding of the basis for such rules.
- The lack of clear, tough academic standards.
- The mind-set that academic success is mostly determined by family background rather than by hard work.
- Overwhelming demands placed on teachers without adequate professional development or time.
- The low status awarded teachers within our culture.
- Demographic factors, such as inequitable school funding, and the associated phenomenon of tracking some students into less challenging curricula.

Exhibit 1. Number of mathematics topics intended. On average, the states indicated plans to cover so many topics that the U.S. composite shows an intention to cover more mathematics topics than the majority of other countries. The number of topics to be covered dropped below the 75th percentile internationally only in grades 9, 10, 11 and 12 when we typically teach mathematics TIMSS countries. The bars extend from the 25th percentile to the 75th percentile among countries. The black line indicates the median number of topics at each grade. We marked the U.S., Germany, and Japan individually.]



http://ustimss.msu.edu/

The Students Explain[1]

1. In trying to make their thoughts clear for other people, student achieve greater clarity for themselves.

2. The students themselves determine what it is they want to understand.

3. People come to depend on themselves.

4. Students recognize the powerful experience of having their ideas taken seriously, rather than simply screened for correspondence to what the teacher wanted.

5. Students learn an enormous amount from each other.

6. Learners come to recognize knowledge as a human construction, since they have constructed their own knowledge and know that they have.

[1]Duckworth, E. 1987. *The having of wonderful ideas" & other essays on teaching and learning*. New York: Teachers College Press.

These problems are endemic to all institutions of education, regardless of level. Children sit for 12 years in classrooms where the implicit goal is to listen to the teacher and memorize the information in order to regurgitate it on a test. Little or no attention is paid to the learning process, even though much research exists documenting that real understanding is a case of active restructuring on the part of the learner. *Restructuring occurs through engagement in problem posing as well as problem solving, inference making and investigation, resolving of contradictions, and reflecting. These processes all mandate far more active learners, as well as a different model of education than the one subscribed to at present by most institutions. Rather than being powerless and dependent on the institution, learners need to be empowered to think and to learn for themselves. Thus, learning needs to be conceived of as something a learner does, not something that is done to a learner.*

Fosnot, C.T. (1989). Enquiring teachers, enquiring learners. NY: Teachers College Press.

Constructivist Learning

Constructivism is not a theory about teaching. It's a theory about knowledge and learning...the theory defines knowledge as temporary, developmental, socially and culturally mediated, and thus, non-objective.

Learning from this perspective is understood as a self-regulated process of resolving inner cognitive conflicts that often become apparent through concrete experience, collaborative discourse, and reflection.

Five overarching principles of constructivist pedagogy:

1. posing problems of emerging relevance to learners;

2. structuring learning around "big ideas" or primary concepts;

3. seeking and valuing students' points of view;

4. adapting curriculum to address students' suppositions;

5. assessing student learning in the context of teaching.

--Catherine Twomey Fosnot

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

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