Design and Implementation of Cooperative Learning in Introductory Physics

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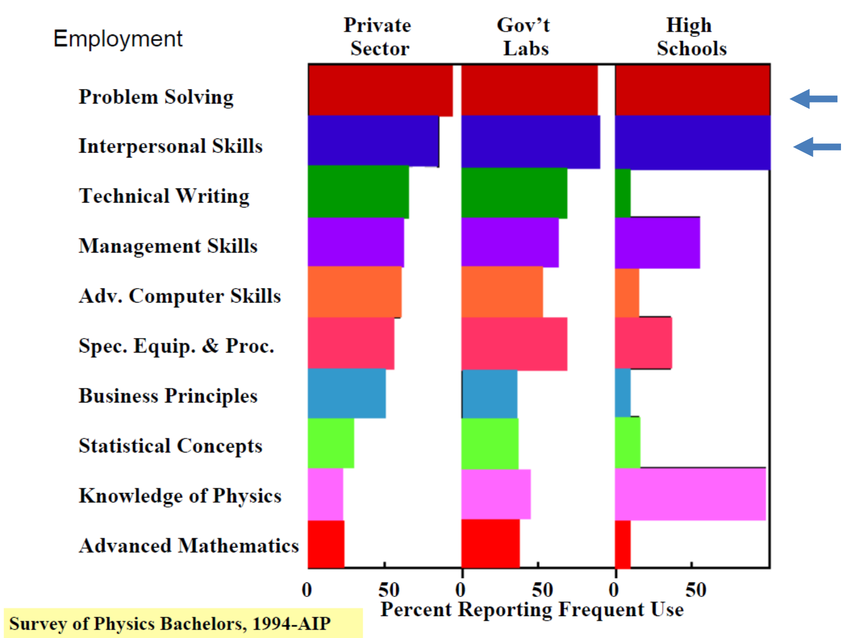
Physics Teaching Assistants Workshop August 29, 2016



Problem Solving *a la* Martinez

"Process of Moving Toward a Goal When Path is Uncertain."

- **If you know how to do it, it's not a problem.**

(Exercise vs Problem)

"Problem Solving Involves Error and Uncertainty"

A problem for your students is not a problem for you.

M. Martinez, Phi Delta Kappan, April, 1998

It is strange that we expect students to learn, yet seldom teach them anything about learning. **We expect students to solve problems, yet seldom teaching them anything about problem solving.** And, similarly, we sometimes require students to remember A considerable body of material, yet seldom teach them the art of memory. It is time we Made up for this lack…

D.A. Norman. 1980. Cognitive engineering and education. In D.T. Tuma and F. Reif (Eds.), *Problem solving and education: Issues in teaching and research. Erlbaum, pp. 97-107.*

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Session Layout

Welcome & Overview

Cooperative Learning
- Description & Rationale
- Cooperative Learning
  - Key Concepts
  - Types of Cooperative Learning

Teamwork – High Performing Teams & Teamwork Skills

Implementing Cooperative Learning
- Practice
- Examples
- Applications

5

Overall Goals

- Build your knowledge of Cooperative Learning and your implementation repertoire
- Implement practices to improve student learning, especially their problem solving skills

6

Cooperative Learning Objectives

Participants will be able to list and describe essential features of the instructor's role in implementing cooperative learning

Participants will be able to elaborate on multiple ways Positive Interdependence and Individual Accountability were structured

Participants will identify features to implement in their own courses

Karl's Introduction to Cooperative Learning

First Teaching Experience – Third-year course in metallurgical reactions – thermodynamics and kinetics

Process Metallurgy

Dissolution Kinetics – liquid-solid interface

Iron Ore Desliming – solid-solid interface

Metal-oxide reduction roasting – gas-solid interface

Dissolution Kinetics

Theory – Governing Equation for Mass Transport

Research – rotating disk

Practice – leaching of silver bearing metallic copper and printed circuit board waste

$$(\nabla c \bullet \underline{v}) = D\nabla^2 c$$

$$v_y \frac{dc}{dy} = D\frac{d^2 c}{dy^2}$$

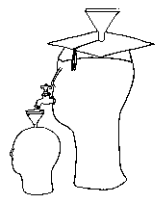
Lila M. Smith

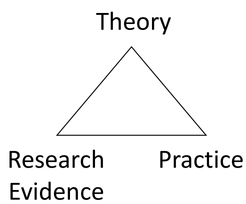
Karl's Quandry

Practice – Third-year course in metallurgical reactions – thermodynamics and kinetics

Theory – ?

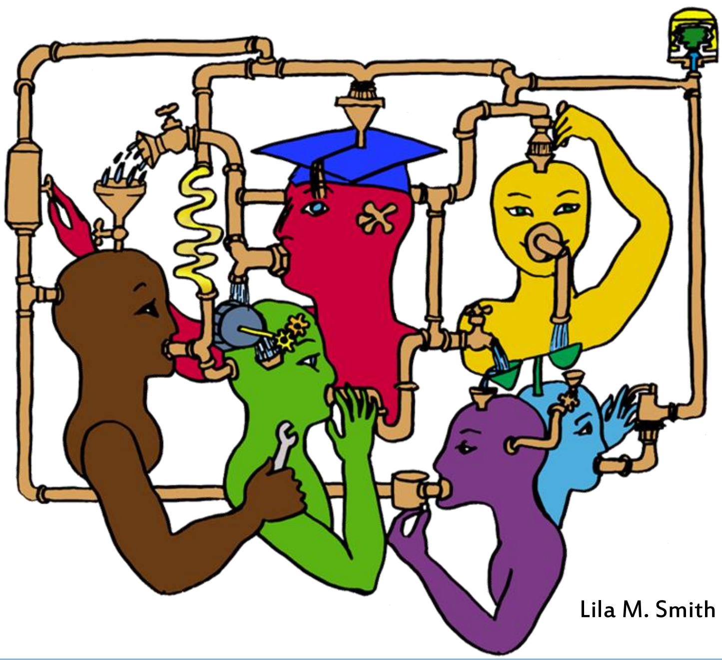
Research – ?





University of Minnesota College of Education Social, Psychological and Philosophical Foundations of Education

- Statistics, Measurement, Research Methodology
- Assessment and Evaluation
- Learning and Cognitive Psychology
- Knowledge Acquisition, Artificial Intelligence, Expert Systems
- Development Theories
- Motivation Theories
- Social psychology of learning – student – student interaction



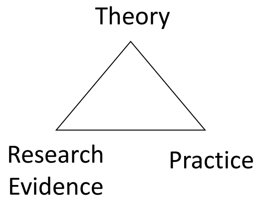
Lila M. Smith

Cooperative Learning

Theory – Social Interdependence – Lewin – Deutsch – Johnson & Johnson

Research – Randomized Design Field Experiments

Practice – Formal Teams/Professor's Role



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

http://personal.cege.umn.edu/~smith/docs/Smith-CL%20Handout%2008.pdf

Cooperative Learning Introduced to Engineering – 1981

Smith, K.A., Johnson, D.W. and Johnson, R.T., 1981. The use of cooperative learning groups in engineering education. In L.P. Grayson and J.M. Biedenbach (Eds.), *Proceedings Eleventh Annual Frontiers in Education Conference*, Rapid City, SD, Washington: IEEE/ASEE, 26-32.


Structuring Learning Goals To Meet the Goals of Engineering Education

Karl A. Smith, David W. Johnson, and Roger T. Johnson
University of Minnesota

JEE December 1981

http://personal.cege.umn.edu/~smith/docs/Smith-Pedagogies_of_Engagement.pdf

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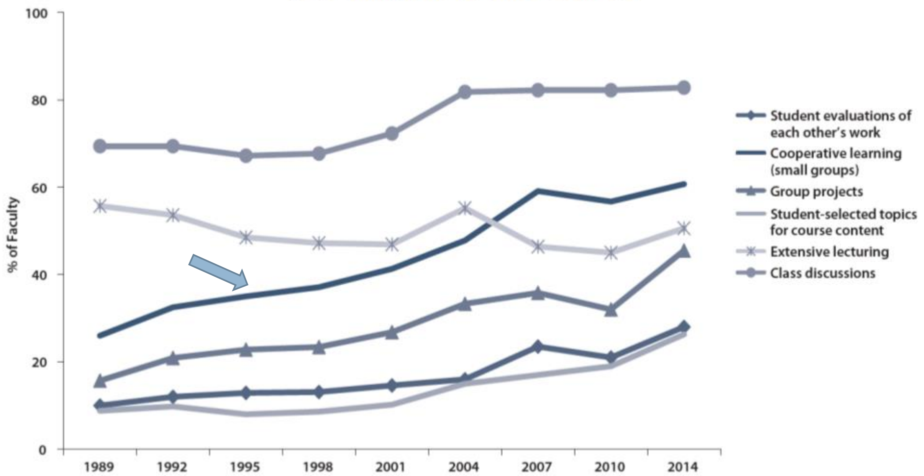
Undergraduate Teaching Faculty: The 2013–2014 HERI Faculty Survey

Figure 2. Changes in Faculty Teaching Practices, 1989 to 2014
(% Marking "All" or "Most" Courses)



http://heri.ucla.edu/monographs/HERI-FAC2014-monograph.pdf

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Cooperative Learning Research Support

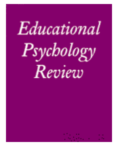
Johnson, D.W., Johnson, R.T., & Smith, K.A. 1998. Cooperative learning returns to college: What evidence is there that it works? *Change*, *30* (4), 26-35.

- 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

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. Journal on Excellence in College Teaching, *25*(3&4)

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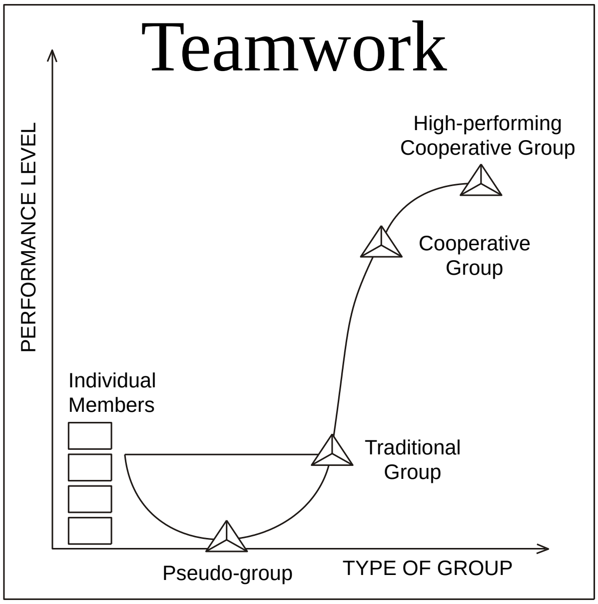
Structuring Teamwork in the Classroom

Formal Cooperative Learning Task Groups



Reflection and Dialogue

Individually reflect on the Characteristics of High Performing Teams. Think/Write for about 1 minute

- Base on your experience on high performing teams,
- Or your facilitation of high performing teams in your classes,
- Or your imagination

Discuss with your team for about 2 minutes and record a list

Characteristics of High Performing Teams

- ?
- ?

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 (1993)

The Wisdom of Teams

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).


Cooperative Learning

Positive Interdependence

Individual Accountability

Face-to-Face Interaction

Karl A. Smith

Key Concepts

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

http://personal.cege.umn.edu/~smith/docs/Smith-CL%20Handout%2008.pdf

Six Basic Principles of Team Discipline

Keep membership small

Ensure that members have complimentary skills

Develop a common purpose

Set common goals

Establish a commonly agreed upon working approach

Integrate mutual and individual accountability

Katzenbach & Smith (2001) *The Discipline of Teams*

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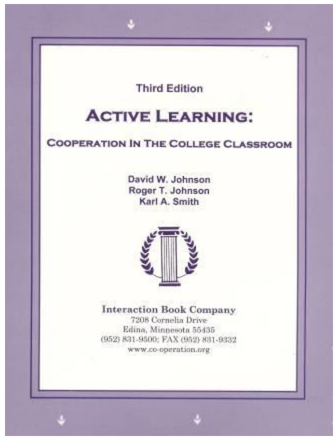
Active Learning: Cooperation in the College Classroom

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

Notes: Cooperative Learning Handout (CL-College-814.doc)
[CL-College-814.doc]



Instructor's Role in Formal Cooperative Learning

1. Specifying **Objectives** (Academic and Interpersonal/Teamwork)
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

Cooperative Problem-Based Learning Format

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

INDIVIDUAL: Develop ideas, Initial Model, Estimate, etc. 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 model and strategies used to solve each problem.

EVALUATION: Best answer within available resources or constraints.

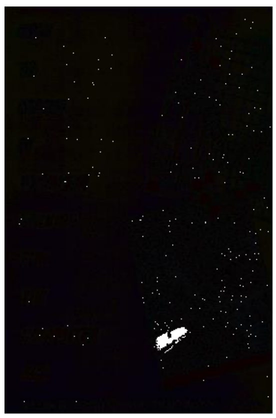
INDIVIDUAL ACCOUNTABILITY: One member from your group may be randomly chosen to explain (a) the answer and (b) how to solve each problem.

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.

Building Models to Solve Engineering Problems – UMN – Institute of Technology course (~1978 – 2000)

- Thinking Like an Engineer
- Problem Identification
- Problem Formulation
- Problem Representation
- Problem Solving



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Team Member Roles

- Task Recorder
- Skeptic/Prober
- Process Recorder

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Technical Estimation Problem

TASK:

INDIVIDUAL: Quick Estimate (10 seconds). Note strategy.
Note strategy.

COOPERATIVE: Improved Estimate (~5 minutes). One set of answers from the group, strive for agreement, make sure everyone is able to explain the strategies used to arrive at the improved estimate.

EXPECTED CRITERIA FOR SUCCESS: Everyone must be able to explain the strategies used to arrive at your improved estimate.

EVALUATION: Best answer within available resources or constraints.

INDIVIDUAL ACCOUNTABILITY: One member from your group may be randomly chosen to explain (a) your estimate and (b) how you arrived at it.

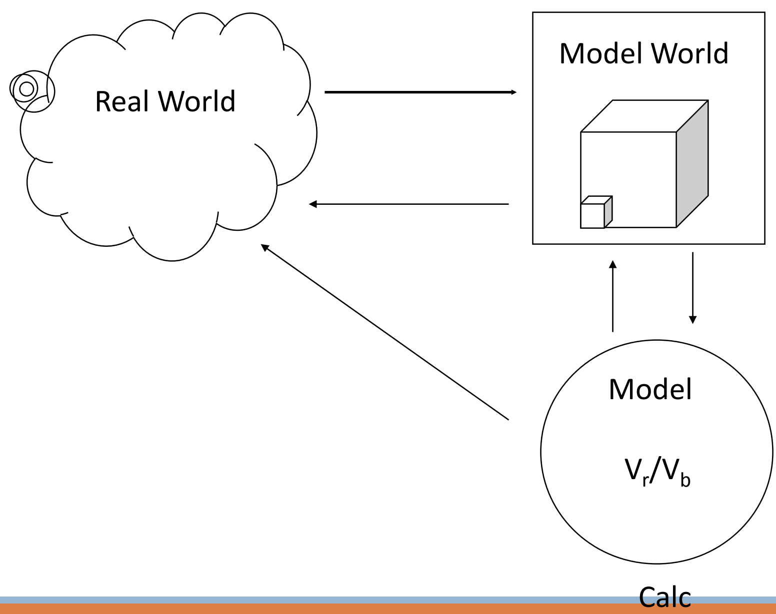
EXPECTED BEHAVIORS: Active participating, checking, encouraging, and elaborating by all members.

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

Group Reports

Estimate
- Group 1
- Group 2
- . . .

Strategy used to arrive at estimate – assumptions, model, method, etc.



Modeling

Modeling in its broadest sense is the cost-effective use of something in place of something else for some cognitive purpose (Rothenberg, 1989). A model represents reality for the given purpose; the model is an abstraction of reality in the sense that it cannot represent all aspects of reality.

Any model is characterized by three essential attributes: (1) *Reference*: It is *of* something (its "*referent*"); (2) *Purpose*: It has an intended cognitive *purpose* with respect to its referent; (3) *Cost-effectiveness:* It is more *cost-effective* to use the model for this purpose than to use the referent itself.

Rothenberg, J. 1989. The nature of modeling. In L.E. Widman, K.A. Laparo & N.R. Nielson, Eds., *Artificial intelligence, simulation and modeling*. New York: Wiley

Modeling Heuristics

Ravindran, Phillips, and Solberg (1987):

1. **Do not build a complicated model when a simple one will suffice.**
2. Beware of molding the problem to fit the technique.
3. The deduction phase of modeling must be conducted rigorously.
4. Models should be validated prior to implementation.
5. A model should never be taken too literally.
6. A model should neither be pressed to do, nor criticized for failing to do, that for which it was never intended.
7. Beware of overselling a model.
8. **Some of the primary benefits of modeling are associated with the process of developing the model.**
9. **A model cannot be any better than the information that goes into it.**
10. Models cannot replace decision makers.

Heuristics - Koen

An essential aspect of modeling is the use of heuristics. Although difficult to define, heuristics are relatively easy to identify using the characteristics listed by Koen(1984): (1) Heuristics do not guarantee a solution; (2) Two heuristics may contradict or give different answers to the same question and still be useful; (3) Heuristics permit the solving of unsolvable problems or reduce the search time to a satisfactory solution; (4) The heuristic depends on the immediate context instead of absolute truth as a standard of validity. A heuristic is anything that provides a plausible aid or direction in the solution of a problem but is in the final analysis unjustified, incapable of justification, and fallible. It is used to guide, to discover, and to reveal.

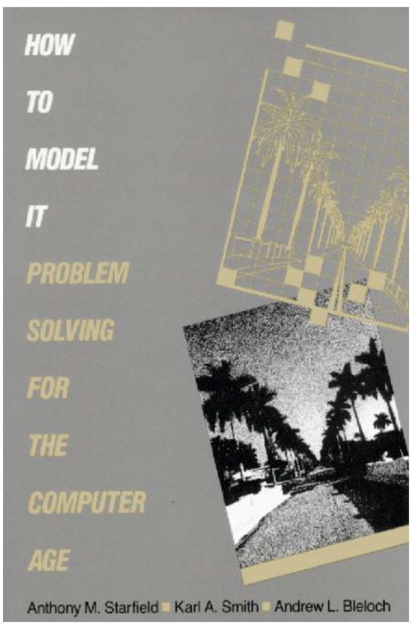
Koen, Billy V. 1984. *Definition of the engineering method.* Washington, DC: ASEE.

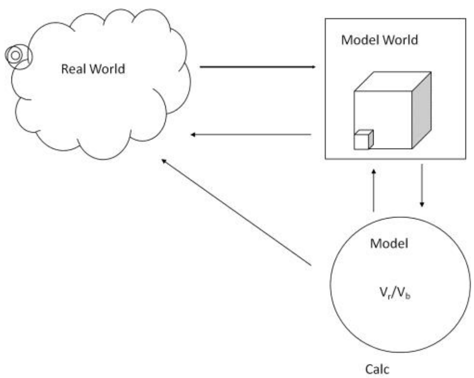
Heuristics are also a key part of the Koen's definition of the engineering method: ***The engineering method is the use of heuristics to cause the best change in a poorly understood situation within the available resources*** (p. 70). Typical engineering heuristics include:

(1) Rules of thumb and orders of magnitude;
(2) Factors of safety;
(3) Heuristics that determine the engineer's attitude toward his or her work;
(4) Heuristics that engineers use to keep risk within acceptable bounds; and
(5) Rules of thumb that are important in resource allocation.

Group Processing Plus/Delta Format

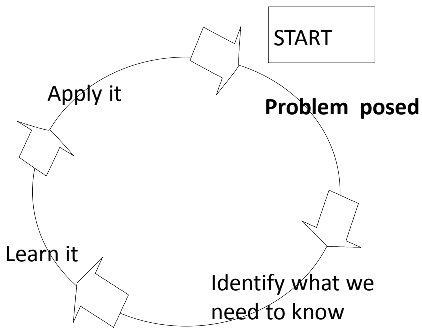
Plus (+) Things That Group Did Well	Delta (Δ) Things Group Could Improve



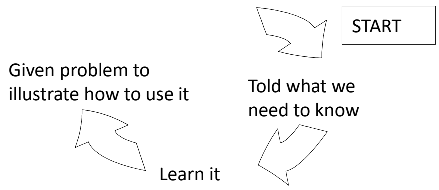


*Based on First Year Engineering course – Problem-based cooperative learning *How to Model It* published in 1990.

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 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).

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http://personal.cege.umn.edu/~smith/docs/Smith-CL%20Handout%2008.pdf

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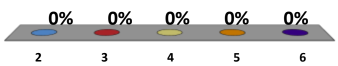
5. **Evaluating** Students' Achievement and Group Effectiveness

Decisions, Decisions…

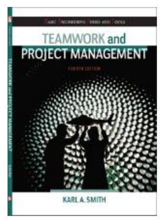
- Group size?
- Group selection?
- Group member roles?
- How long to leave groups together?
- Arranging the room?
- Providing materials?
- Time allocation?

Optimal Group Size?

A. 2
B. 3
C. 4
D. 5
E. 6



Formal Cooperative Learning Task Groups



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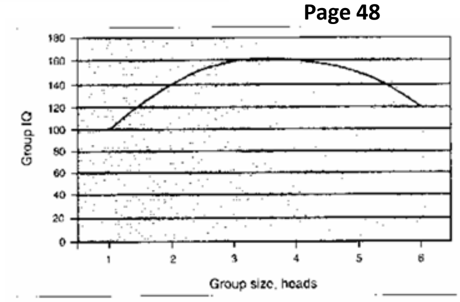
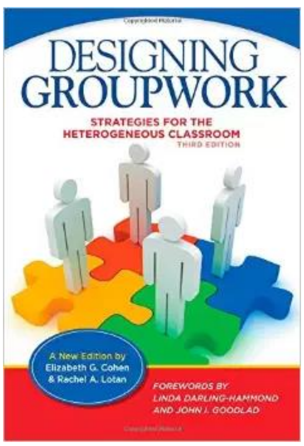


Perkins, David. 2003. *King Arthur's Round Table: How collaborative conversations create smart organizations.* NY: Wiley.

Group Selection?

A. Self selection
B. Random selection
C. Stratified random
D. Instructor assign
E. Other

Assigning Roles

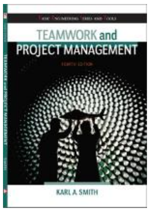


Chapter 8: Group Roles and Responsibilities

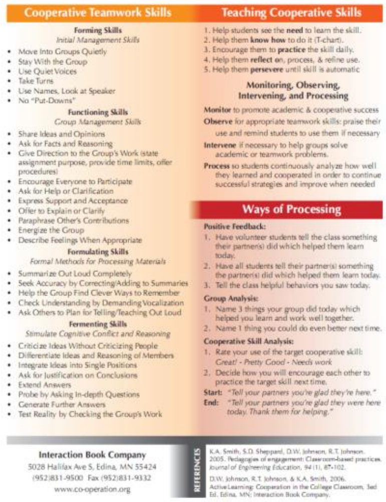
- Roles
  - Facilitator
  - Checker
  - Set-Up
  - Materials Manager
  - Safety Officer
  - Reporter
- Dividing the labor

Teamwork Skills

- Communication
  - Listening and Persuading
- Decision Making
- Conflict Management
- Leadership
- Trust and Loyalty



Chapters 3, **4**, 5 & 6



Cooperative Teamwork Skills

Forming Skills
Initial Management Skills
- Move Into Groups Quietly
- Stay With the Group
- Use Quiet Voices
- Take Turns
- Use Names, Look at Speaker
- No "Put-Downs"

Functioning Skills
Group Management Skills
- Share Ideas and Opinions
- Ask for Facts and Reasoning
- Give Direction to the Group's Work (state assignment purpose, provide time limits, offer procedures)
- Encourage Everyone to Participate
- Ask for Help or Clarification
- Express Support and Acceptance
- Offer to Explain or Clarify
- Paraphrase Other's Contributions
- Energize the Group
- Describe Feelings When Appropriate

Formulating Skills
Formal Methods for Processing Materials
- Summarize Out Loud Completely
- Seek Accuracy by Correcting/Adding to Summaries
- Help the Group Find Clever Ways to Remember
- Check Understanding by Demanding Vocalization
- Ask Others to Plan for Telling/Teaching Out Loud

Fermenting Skills
Stimulate Cognitive Conflict and Reasoning
- Criticize Ideas Without Criticizing People
- Differentiate Ideas and Reasoning of Members
- Integrate Ideas into Single Positions
- Ask for Justification on Conclusions
- Extend Answers
- Probe by Asking In-depth Questions
- Generate Further Answers
- Test Reality by Checking the Group's Work

Teaching Cooperative Skills

1. Help students see the **need** to learn the skill.
2. Help them **know how** to do it (T-chart).
3. Encourage them to **practice** the skill daily.
4. Help them **reflect on**, process, & refine use.
5. Help them **persevere** until skill is automatic

Monitoring, Observing, Intervening, and Processing

Monitor to promote academic & cooperative success
Observe for appropriate teamwork skills: praise their use and remind students to use them if necessary
Intervene if necessary to help groups solve academic or teamwork problems.
Process so students continuously analyze how well they learned and cooperated in order to continue successful strategies and improve when needed

Ways of Processing

Positive Feedback:
1. Have volunteer students tell the class something their partner(s) did which helped them learn today.
2. Have all students tell their partner(s) something the partner(s) did which helped them learn today.
3. Tell the class helpful behaviors you saw today.

Group Analysis:
1. Name 3 things your group did today which helped you learn and work well together.
2. Name 1 thing you could do even better next time.

Cooperative Skill Analysis:
1. Rate your use of the target cooperative skill: *Great! - Pretty Good - Needs work*
2. Decide how you will encourage each other to practice the target skill next time.

Start: *"Tell your partners you're glad they're here."*
End: *"Tell your partners you're glad they were here today. Thank them for helping."*

Interaction Book Company
5028 Halifax Ave S, Edina, MN 55424
(952)831-9500 Fax (952)831-9332
www.co-operation.org

REFERENCES

K.A. Smith, S.D. Sheppard, D.W. Johnson, R.T. Johnson. 2005. Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education*, 94 (1), 87-102.

D.W. Johnson, R.T. Johnson, & K.A. Smith, 2006. Active Learning: Cooperation in the College Classroom, 3rd Ed. Edina, MN: Interaction Book Company.

TEAMWORK

Teaching Cooperative Skills

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Observe for appropriate teamwork skills: praise their use and remind students to use them if necessary

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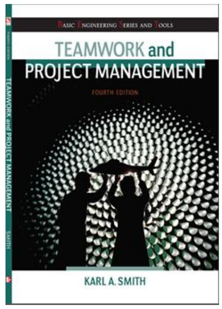
Process so students continuously analyze how well they learned and cooperated in order to continue successful strategies and improve when needed

Team Charter

- Team name, membership, and roles
- Team mission
- Anticipated results (goal)
- Specific tactical objectives
- **Ground rules/ Guiding principles for team participation**
- Shared expectations/aspirations



pp. 60-61, 204-205

Group Ground Rules Contract Form
(Adapted from a form developed by Dr. Deborah Allen, University of Delaware)

Project groups are an effective aid to learning, but to work best they require that all groups members clearly understand their responsibilities to one another. These project group ground rules describe the general responsibilities of every member to the group. You can adopt additional ground rules if your group believes they are needed. Your signature on this contract form signifies your commitment to adhere to these rules and expectations.

All group members agree to:
1. Come to class and team meetings on time.
2. Come to class and team meetings with assignments and other necessary preparations done.

Additional ground rules:
1.

2.

If a member of the project team repeatedly fails to meet these ground rules, other members of the group are expected to take the following actions:

Step 1: (fill in this step with your group)

If not resolved:
Step 2: Bring the issue to the attention of the teaching team.
If not resolved:
Step 3: Meet as a group with the teaching team.

The teaching team reserves the right to make the final decisions to resolve difficulties that arise within the groups. Before this becomes necessary, the team should try to find a fair and equitable solution to the problem.

Member's Signatures: Group Number:_____________

1.__________________________ 3.__________________________

2.__________________________ 4.__________________________

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Reflection and Dialogue

Individually reflect on **rationale** for Teamwork and Cooperative Learning. Write for about 1 minute.

- Context/Audience – Introductory Physics course
- Why cooperative learning and teamwork are important?
- What support do you have for your rationale?

Discuss with your neighbor for about 2 minutes

- Select/create a response to present to the whole group if you are randomly selected

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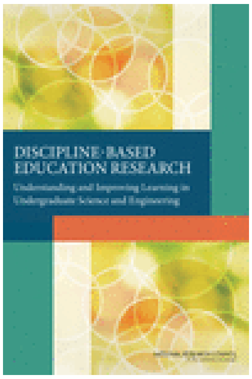
Why Emphasize Cooperative Learning and Teamwork?

- **Student learning**
- Essential **transferrable skill** development
- Key to **innovation**
- High priority for **Employers**

Discipline-Based Education Research (DBER) Report



National Research Council Summer 2012 – http://www.nap.edu/catalog.php?record_id=13362

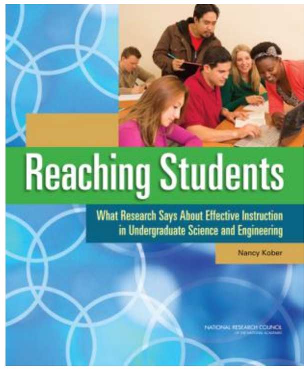

LAST WORD

Follow the Evidence

STUDENTS ARE CHALLENGED BY KEY ASPECTS OF ENGINEERING AND SCIENCE THAT CAN SEEM EASY OR OBVIOUS TO EXPERTS.

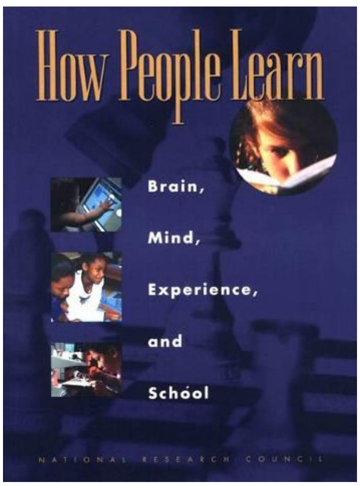
ASEE *Prism Summer 2013*

Journal of Engineering Education – October, 2013



National Research Council – 2015 http://www.nap.edu/catalog/18687/reaching-students-what-research-says-about-effective-instruction-in-undergraduate

Expertise Implies:



a set of cognitive and metacognitive skills

an organized body of knowledge that is deep and contextualized

an ability to notice patterns of information in a new situation

flexibility in retrieving and applying that knowledge to a new problem

Bransford, Brown & Cocking. 1999. *How people learn.* National Academy Press.

Acquisition of Expertise

Fitts P, & Posner MI. Human Performance. Belmont, CA: Brooks/Cole, 1967.

Cognition: Learn from instruction or observation what knowledge and actions are appropriate

Associative: Practice (with feedback) allowing smooth and accurate performance

Automaticity: "Compilation" or performance and associative sequences so that they can be done without large amounts of cognitive resources

"The secret of expertise is that there is no secret. It takes at least 10 years of concentrated effort to develop expertise." Herbert Simon

Learning Requires

deliberate

distributed

practice

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Key Implications

Deliberate

Attention must be paid

Attention and processing power = cognitive load (bandwidth)

- LIMITED – need to be careful how one uses the learner's bandwidth
  - Link to Curricular Priorities
- Continuous partial attention

- Reflection is needed
  - Need for feedback
    - Link to assessment

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Key Implications

Distributed

Repetition <u>over time</u>

- Spaced vs. massed practice*
- Spiral curriculum

Multiple modes of input

- Visual
- Audio
- Kinesthetic
- Self-explanation
- Explaining to others

*Kandel, E.B. 2007. In Search of Memory: The Emergence of a New Science of Mind. New York: Norton.

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Key Implications

Practice what you want to learn

Active – doing something

Constructive – adding to your prior knowledge

Interactive – working with others to add to your prior knowledge

Chi, M.T.H. 2009. Active-Constructive-Interactive: A Conceptual Framework for Differentiating Learning Activities. *Topics in Cognitive Science 1*, 73–105.

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Cognitive apprenticeship (1 of 3)

1. Authentic tasks/situations
2. Narrated modeling
   - Challenges of this approach
     - Expert not used to explaining thinking
     - Expert forgets what is it like to be learning the material, "expert blind spot"
     - Subconscious or intuitive knowledge - "mystery of expert judgment"

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Cognitive apprenticeship (2 of 3)

3. Scaffolded and coached practice
   - Scaffold from learner's prior knowledge to new info
   - Coach can diagnose "problems" and correct
   - Immediate feedback – important for motivation
   - Informational feedback

Cognitive apprenticeship (3 of 3)

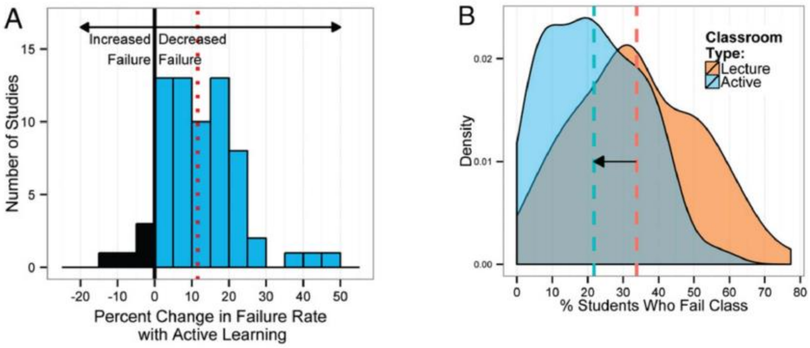
3. Articulation of the steps by the learner
   - Self-explanation
4. Reflection on the process by the learner
   - Consolidates the skill, improves retention

Collins, A., Brown, J. S., & Newman, S. E. (1987). Cognitive apprenticeship: Teaching the craft of reading, writing and mathematics (Technical Report No. 403). BBN Laboratories, Cambridge, MA.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18, 32-42.

Engaged Pedagogies = Reduced Failure Rates

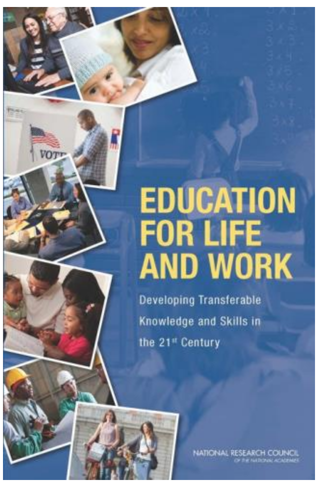
Evidence-based research on learning indicates that when students are actively involved in their education they are more successful and less likely to fail. A new PNAS report by Freeman et al., shows a significant decrease of failure rate in active learning classroom compared to traditional lecture



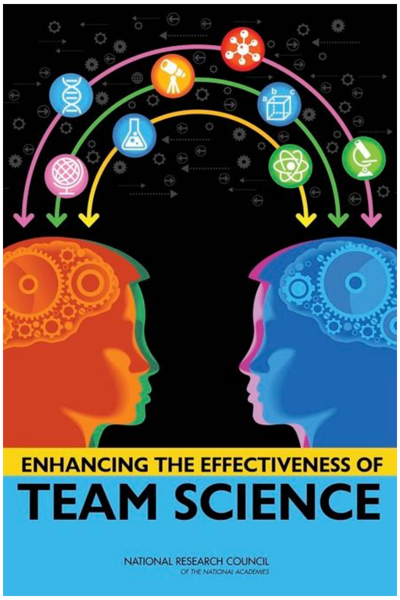
Freeman, Scott; Eddy, Sarah L.; McDonough, Miles; Smith, Michelle K.; Okoroafor, Nnadozie; Jordt, Hannah; Wenderoth, Mary Pat; Active learning increases student performance in science, engineering, and mathematics, 2014, Proc. Natl. Acad. Sci.

83

Education for Life and Work

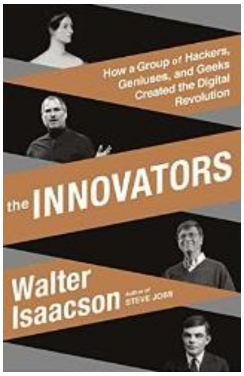


http://www.nap.edu/catalog/13398/education-for-life-and-work-developing-transferable-knowledge-and-skills



Conclusion. A strong body of research conducted over several decades has demonstrated that ***team processes*** *(e.g., shared understanding of team goals and member roles, conflict)* ***are related to team effectiveness****. Actions and interventions that foster positive team processes offer the most promising route to enhance team effectiveness; they target three aspects of a team: team composition (assembling the right individuals), team professional development, and team leadership. (p. 7)*

http://www.nap.edu/catalog/19007/enhancing-the-effectiveness-of-team-science



This is the story of these pioneers, hackers, inventors, and entrepreneurs – who they were, how their minds worked, and what made them so creative. It's also a narrative of **how they collaborated and why their ability to work as teams made them even *more* creative.** The tale of their teamwork is important because we don't often focus on how central that skill is to innovation.

Falling Short?
College Learning and Career Success

HART RESEARCH ASSOCIATES

Selected Findings from Online Surveys of Employers and College Students Conducted on Behalf of the Association of American Colleges & Universities

By Hart Research Associates

Embargoed Until January 20, 2015, 12:01 a.m.

Learning Outcomes Four in Five Employers Rate as Very Important
(Proportion of employers who rate each outcome an 8, 9, or 10 on a zero-to-10 scale)

	Employers %
The ability to effectively communicate orally	85
The ability to work effectively with others in teams	83
The ability to effectively communicate in writing	82
Ethical judgment and decision-making	81
Critical thinking and analytical reasoning skills	81
The ability to apply knowledge and skills to real-world settings	80

http://www.aacu.org/leap/public-opinion-research/2015-survey-results

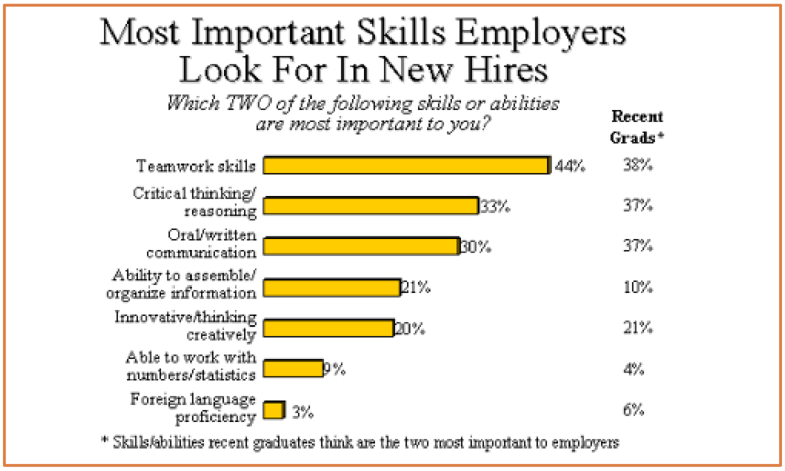
How Should Colleges Prepare Students To Succeed In Today's Global Economy?

Based On Surveys Among Employers And Recent College Graduates

Conducted On Behalf Of:
The Association Of American Colleges And Universities

By Peter D. Hart Research Associates, Inc.

December 28, 2006



http://www.aacu.org/advocacy/leap/documents/Re8097abcombined.pdf

The College Degrees And **Skills** Employers Most Want In 2015 (National Association of Colleges and Employers (NACE))

The NACE survey also asked employers to rate **the skills they most value in new hires**. Companies want candidates who can think critically, solve problems, work in a team, maintain a professional demeanor and demonstrate a strong work ethic. Here is the ranking in order of importance:

Competency	Essential Need Rating*
Critical Thinking/Problem Solving	4.7
Teamwork	4.6
Professionalism/Work Ethic	4.5
Oral/Written Communications	4.4
Information Technology Application	3.9
Leadership	3.9
Career Management	3.6

*Weighted average. Based on a 5-point scale where 1=Not essential, 2=Not very essential; 3=Somewhat essential; 4=Essential; 5=Absolutely essential

http://www.forbes.com/sites/susanadams/2015/04/15/the-college-degrees-and-skills-employers-most-want-in-2015/

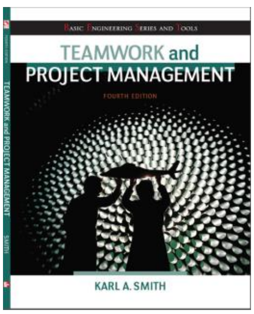
Top Three Main Engineering Work Activities

Engineering Total

- Design – 36%
- Computer applications – 31%
- Management – 29%

Civil/Architectural

- Management – 45%
- Design – 39%
- Computer applications – 20%



Burton, L., Parker, L, & LeBold, W. 1998. U.S. engineering career trends. *ASEE Prism*, *7*(9), 18-21.

Designing and Implementing Cooperative Learning

Think like a designer

Ground practice in robust theoretical framework

Start small, start early and iterate

Celebrate the successes; problem-solve the failures

The Instructor's Role in Cooperative Learning

Make Pre-Instructional Decisions

Specify Academic and Teamwork Skills Objectives: Every lesson has both (a) academic and (b) interpersonal and small group (teamwork) skills objectives.

Decide on Group Size: Learning groups should be small (groups of two or three members, four at the most).

Decide on Group Composition (Assign Students to Groups): Assign students to groups randomly or select groups yourself. Usually you will wish to maximize the heterogeneity in each group.

Assign Roles: Structure student-student interaction by assigning roles such as Reader, Recorder, Encourager of Participation and Checker for Understanding.

Arrange the Room: Group members should be "knee to knee and eye to eye" but arranged so they all can see the instructor at the front of the room.

Plan Materials: Arrange materials to give a "sink or swim together" message. Give only one paper to the group or give each member part of the material to be learned.

Explain Task And Cooperative Structure

Explain the Academic Task: Explain the task, the objectives of the lesson, the concepts and principles students need to know to complete the assignment and the procedures they are to follow.

Explain the Criteria for Success: Student work should be evaluated on a criteria-referenced basis. Make clear your criteria for evaluating students' work.

***Structure Positive Interdependence**: Students must believe they "sink or swim together." Always establish mutual goals (students are responsible for their own learning and the learning of all other group members). Supplement, goal interdependence with celebration/reward, resource, role, and identity interdependence.

Structure Intergroup Cooperation: Have groups check with and help other groups. Extend the benefits of cooperation to the whole class.

***Structure Individual Accountability**: Each student must feel responsible for doing his or her share of the work and helping the other group members. Ways to ensure accountability are frequent oral quizzes of group members picked at random, individual tests, and assigning a member the role of Checker for Understanding.

***Specify Expected Behaviors**: The more specific you are about the behaviors you want to see in the groups, the more likely students will do them. Social skills may be classified as **forming** (staying with the group, using quiet voices), **functioning** (contributing, encouraging others to participate), **formulating** (summarizing, elaborating), and **fermenting** (criticizing ideas, asking for justification). Regularly teach the interpersonal and small group skills you wish to see used in the learning groups.

Monitor and Intervene

***Arrange Face-to-Face Promotive Interaction**: Conduct the lesson in ways that ensure that students promote each other's success face-to-face.

Monitor Students' Behavior: This is the fun part! While students are working, you circulate to see whether they understand the assignment and the material, give immediate feedback and reinforcement, and praise good use of group skills. Collect observation data on each group and student.

Intervene to Improve Taskwork and Teamwork: Provide **taskwork assistance** (clarify, reteach) if students do not understand the assignment. Provide **teamwork assistance** if students are having difficulties in working together productively.

Evaluate and Process

Evaluate Student Learning: Assess and evaluate the quality and quantity of student learning. Involve students in the assessment process.

***Process Group Functioning**: Ensure each student receives feedback, analyzes the data on group functioning, sets an improvement goal, and participates in a team celebration. Have groups routinely list three things they did well in working together an done thing they will do better tomorrow. Summarize as a whole class. Have groups celebrate their success and hard work.

Cooperative Lesson Planning Form

Subject Area: ______________ Date: ______________

Lesson: ______________

Objectives

Academic: ______________

Social Skills: ______________

Preinstructional Decisions

Group Size: ________ Method Of Assigning Students: ______________

Roles: ______________

Room Arrangement: ______________

Materials: ______________

- One Copy Per Group
- One Copy Per Person
- Jigsaw
- Tournament
- Other: ______________

Explain Task And Cooperative Goal Structure

1. Task: ______________
2. Criteria For Success: ______________
3. Positive Interdependence: ______________
4. Individual Accountability: ______________
5. Intergroup Cooperation: ______________
6. Expected Behaviors: ______________

Monitoring And Intervening

1. Observation Procedure: _____ Formal _____ Informal
2. Observation By: _____ Teacher _____ Students _____ Visitors
3. Intervening For Task Assistance: ______________
4. Intervening For Teamwork Assistance: ______________
5. Other: ______________

Evaluating And Processing

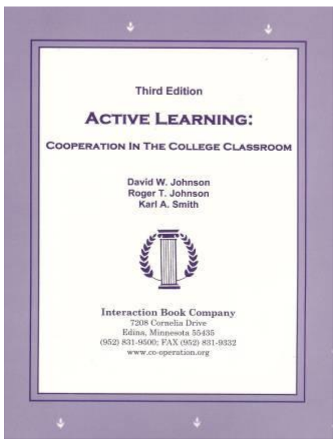
1. Assessment Of Members' Individual Learning: ______________
2. Assessment Of Group Productivity: ______________
3. Small Group Processing: ______________
4. Whole Class Processing: ______________
5. Charts And Graphs Used: ______________
6. Positive Feedback To Each Student: ______________
7. Goal Setting For Improvement: ______________
8. Celebration: ______________
9. Other: ______________

Active Learning: Cooperation in the College Classroom

Informal Cooperative Learning Groups

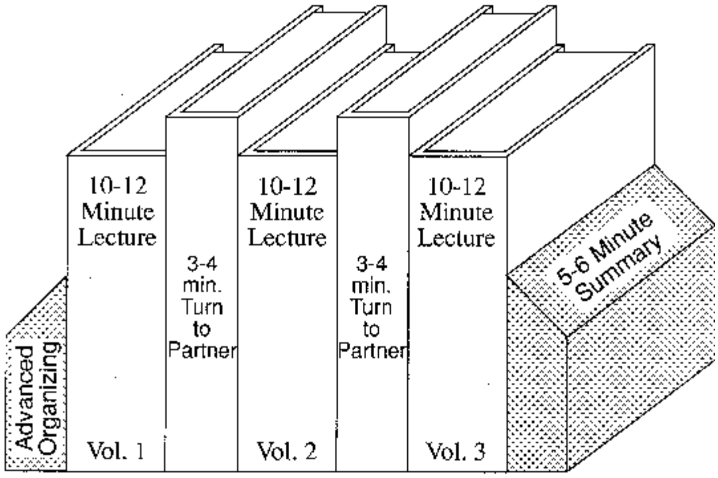
Formal Cooperative Learning Groups

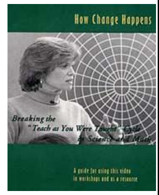
Cooperative **Base** Groups



Notes: Cooperative Learning Handout (CL-College-814.doc)
[CL-College-814.doc]

Book Ends on a Class Session





Smith, K.A. 2000. Going deeper: Formal small-group learning in large classes. Energizing large classes: From small groups to learning communities. *New Directions for Teaching and Learning*, 2000, 81, 25-46. [NDTL81Ch3GoingDeeper.pdf]

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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 (Cognitive Rehearsal)

Are especially effective in large lectures

Include "book ends" procedure

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

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Informal Cooperative Learning Planning Form

Description of the Lecture

1. **Lecture Topic:** ______________________
2. **Objectives** (Major Understandings Students Need To Have At The End Of The Lecture):
   a. ______________________
   b. ______________________
3. **Time Needed:** ______________________
4. **Method For Assigning Students To Pairs Or Triads:** ____________
5. **Method Of Changing Partners Quickly:** ____________
6. **Materials** (such as transparencies listing the questions to be discussed and describing the **formulate, share, listen, create** procedure):
   ____

Advanced Organizer Question(s)

Questions should be aimed at promoting **advance organizing** of what the students know about the topic to be presented and **establishing expectations** as to what the lecture will cover.

1. ______________________
2. ______________________
3. ______________________

Cognitive Rehearsal Questions

List the specific questions to be asked every 10 or 15 minutes to ensure that participants understand and process the information being presented. Instruct students to use the **formulate, share, listen, and create** procedure.

1. ______________________
2. ______________________
3. ______________________
4. ______________________

Monitor by systematically observing each pair. Intervene when it is necessary. Collect data for whole class processing. Students' explanations to each other provide a window into their minds that allows you to see what they do and do not understand. Monitoring also provides an opportunity for you to get to know your students better.

Summary Question(s)

Give an ending discussion task and require students to come to consensus, write down the pair or triad's answer(s), sign the paper, and hand it in. Signatures indicate that students agree with the answer, can explain it, and guarantee that their partner(s) can explain it. The questions could (a) ask for a summary, elaboration, or extension of the material presented or (b) precue the next class session.

1. ______________________
2. ______________________

http://personal.cege.umn.edu/~smith/

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SCALE-UP

Student-Centered Active Learning Environment with Upside-down Pedagogies

How would you like to teach (or learn) in a classroom like this one at MIT?

The purpose of this website is to share designs for state-of-the-art learning studios, teaching methods, and instructional materials that are based on more than a decade of discipline-based education research.

For a quick introduction, visit our Frequently-Asked-Questions page, or take a look at this 5 minute video or view a some of these short video clips created by adopters:

Minnesota, McGill, Iowa, Virginia Tech, Old Dominion, Northern Michigan, Oklahoma, Windward High School

As a visitor to the site, you can view classroom designs and find contact information for scores of colleges and a growing number of high schools that are offering highly interactive, collaborative, guided-inquiry-based instruction.

Registered site members have access to many more details and classroom materials being developed and tested by faculty from around the world.

Visitors may click here to go to pages describing the work of many of the institutions adopting SCALE-UP.

Registered site members, click here to log in. (There is additional detailed information available only to those who have registered.)

http://scaleup.ncsu.edu/

NC STATE UNIVERSITY

Quick Link Click Here

Physics Education Research Group

People
Projects
Publications
Links
Contact Us
Home
lease click here if no
enu appears

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 information.

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

Cooperative Problem-Based Learning

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

Jodi Hilton for The New York Times

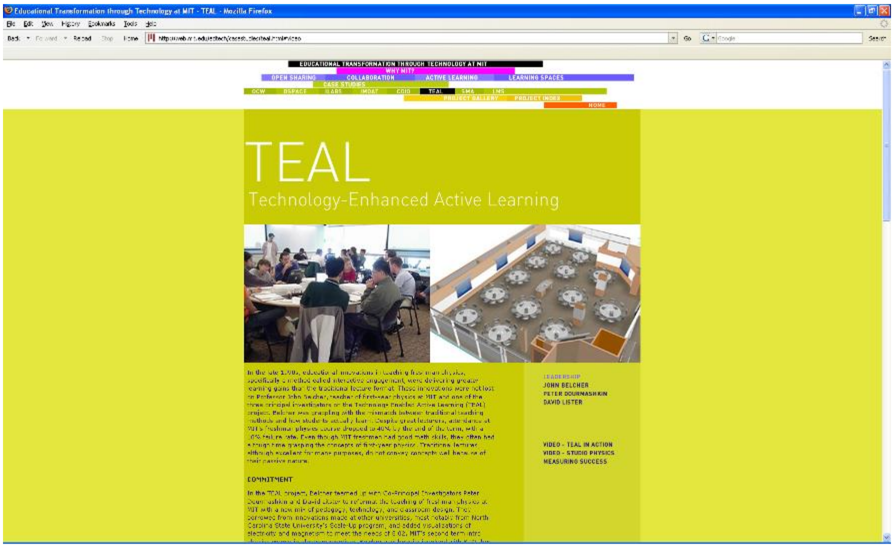
The Massachusetts Institute of Technology has changed the way it offers some introductory classes. Prof. Gabriella Sciolla at a class on electricity and magnetism.

By SARA RIMER
Published: January 12, 2009

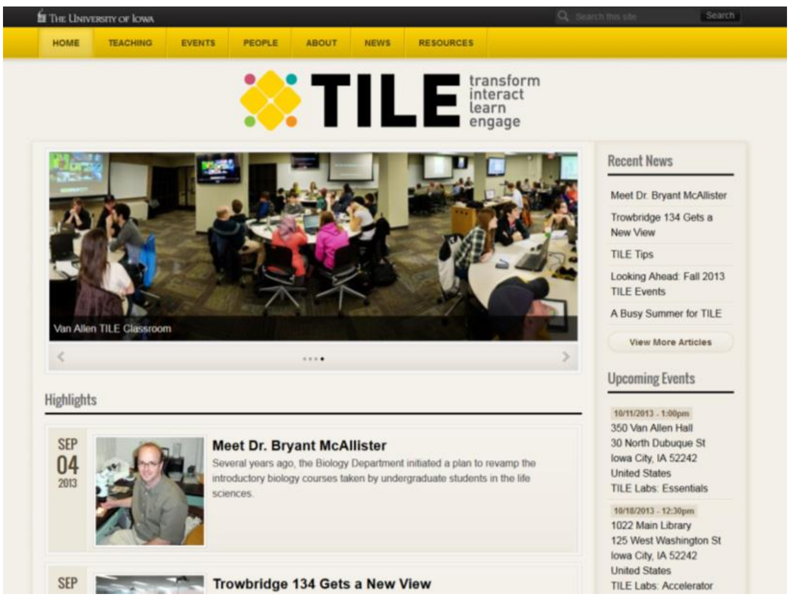
COMMENTS (00)
E-MAIL
PRINT
SINGLE PAGE

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

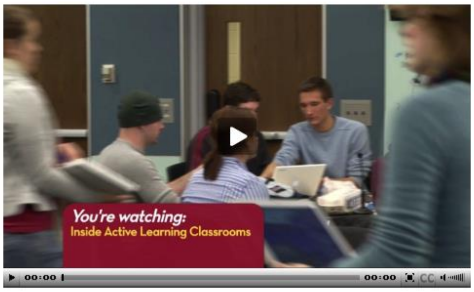


http://web.mit.edu/edtech/casestudies/teal.html#video



http://tile.uiowa.edu/


University of Minnesota
Driven to Discover
UMNews
News Release
U of M dedicates new Science Teaching and Student Services building



http://mediamill.cla.umn.edu/mediamill/embed/78755

http://www1.umn.edu/news/news-releases/2010/UR_CONTENT_248261.html

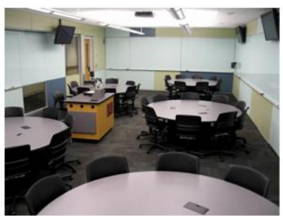
http://www.youtube.com/watch?v=lfT_hoiuY8w

Inside an Active Learning Classroom

STSS at the University of Minnesota

http://vimeo.com/andyub/activeclassroom





"I love this space! It makes me feel appreciated as a student, and I feel intellectually invigorated when I work and learn in it."

http://www.udel.edu/inst/