Teamwork: Insights from 40 years of Research and Practice

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AAPT Summer Meeting

July 28, 2015

Overview

- Why teamwork?
- Teamwork Research Summary
- Structuring Teamwork in the Classroom
- Slides Posted - http://personal.cege.umn.edu/~smith/links.html
  - AAPT Summer Conference 2015
    - Session EK: Research on Teamwork
    - Smith - Teamwork: Insights from 40 years of Research and Practice [Smith-AAPT-Teamwork-v7.pdf]

Rationale for Teamwork

- What is your rationale for incorporating **teamwork?**
- Think/Write for about 1 minute
- Discuss with your neighbors for about 2 minutes and record a list
- Prepare to report out if you are randomly called on

Dissolution Kinetics

- Theory – Governing Equation for Mass Transport
- Research – rotating disk
- Practice – leaching of silver bearing metallic copper & printed circuit-board waste

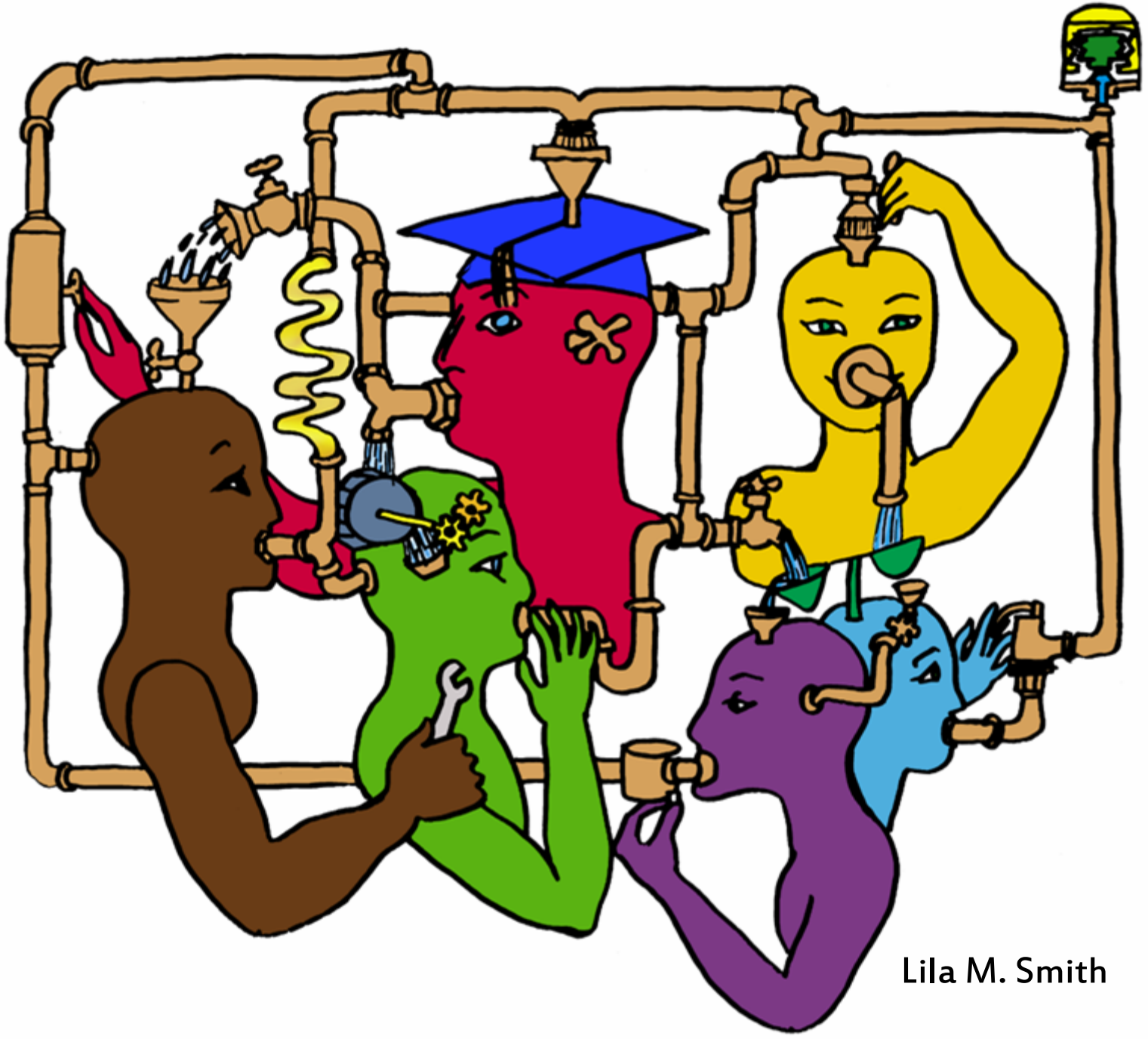
$$(\nabla c \bullet \underline{v}) = D\nabla^2 c$$

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

Lila M. Smith

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 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

Positive Interdependence

Goal Interdependence (essential)
1. All members show mastery
2. All members improve
3. Add group member scores to get an overall group score
4. One product from group that all helped with and can explain

Role (Duty) Interdependence
Assign each member a role and rotate them

Resource Interdependence
1. Limit resources (one set of materials)
2. Jigsaw materials
3. Separate contributions

Task Interdependence
1. Factory-line
2. Chain Reaction

Outside Challenge Interdependence
1. Intergroup competition
2. Other class competition

Identity Interdependence
Mutual identity (name, motto, etc.)

Environmental Interdependence
1. Designated classroom space
2. Group has special meeting place

Fantasy Interdependence
Hypothetical interdependence in situation ("You are a scientific/literary prize team, lost on the moon, etc.")

Reward/Celebration Interdependence
1. Celebrate joint success
2. Bonus points (use with care)
3. Single group grade (when fair to all)

Individual Accountability

Ways to ensure no slackers:
- Keep group size small (2-4)
- Assign roles
- Randomly ask one member of the group to explain the learning
- Have students do work before group meets
- Have students use their group learning to do an individual task afterward
- Everyone signs: "I participated, I agree, and I can explain"
- Observe & record individual contributions

Ways to ensure that all members learn:
- Practice tests
- Edit each other's work and sign agreement
- Randomly check one paper from each group
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- Assign the role of **checker** who has each group member explain out loud
- Simultaneous explaining: each student explains their learning to a new partner

Face-to-Face Interaction

Structure:
- Time for groups to meet
- Group members close together
- Small group size of two or three
- Frequent oral rehearsal
- Strong positive interdependence
- Commitment to each other's learning
- Positive social skill use
- Celebrations for encouragement, effort, help, and success!

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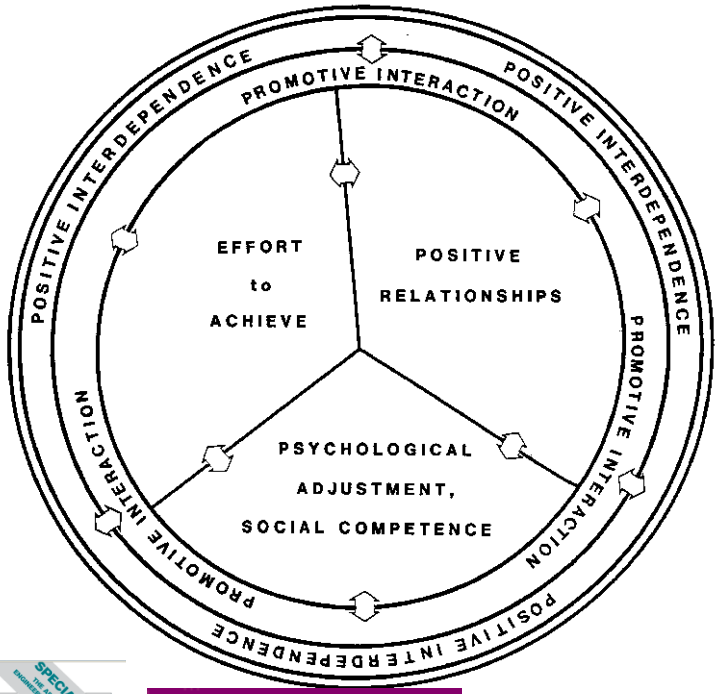
Cooperative Learning Research Support

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.

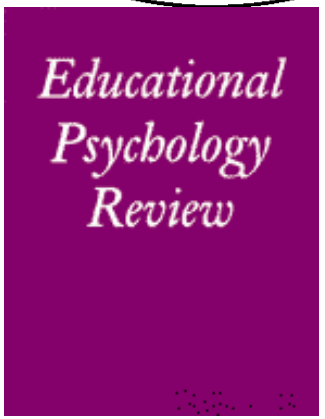
- Over 300 Experimental Studies
- First study conducted in 1924
- High Generalizability
- Multiple Outcomes



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

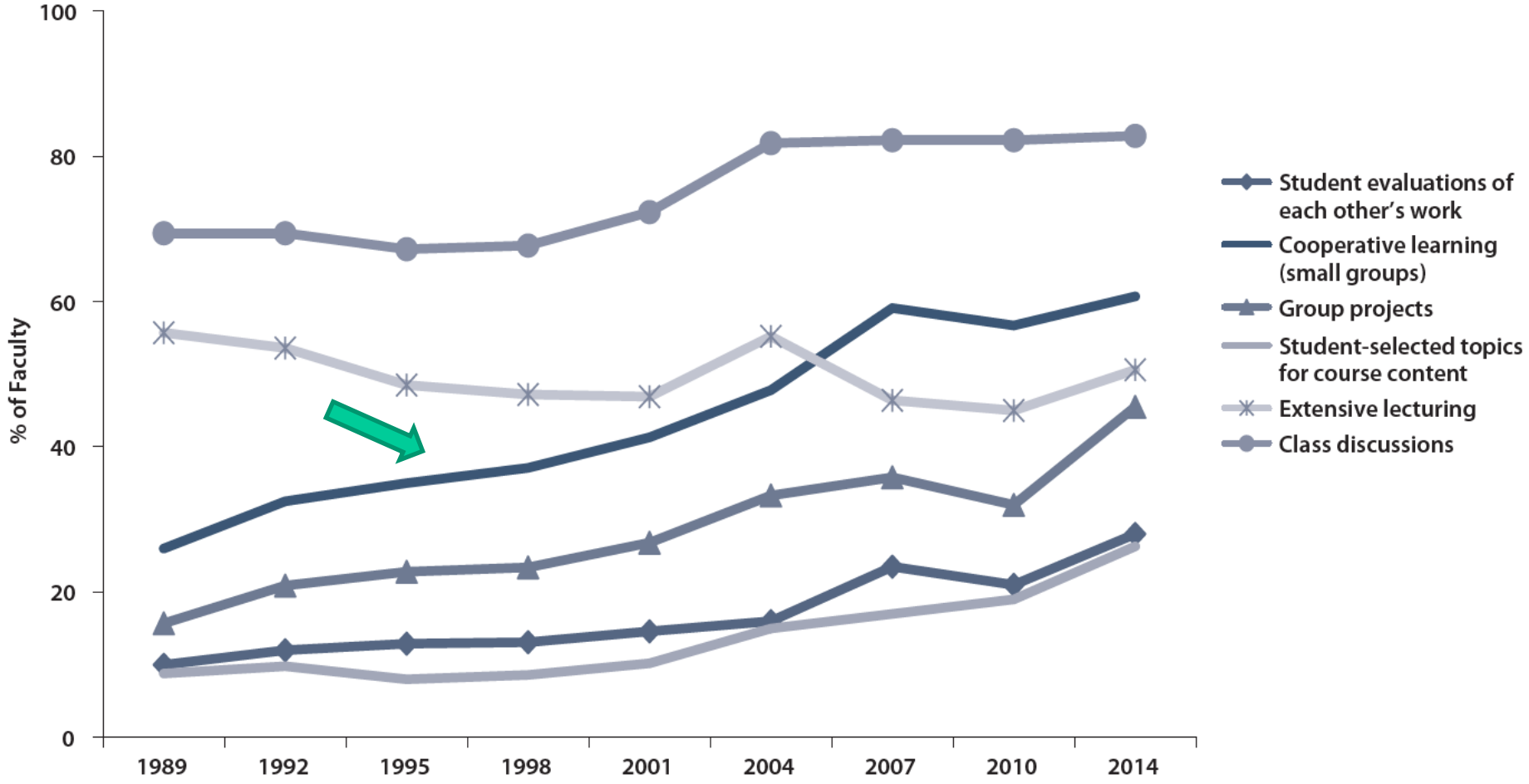


March 2007

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)

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

Undergraduate Teaching Faculty, 2011*

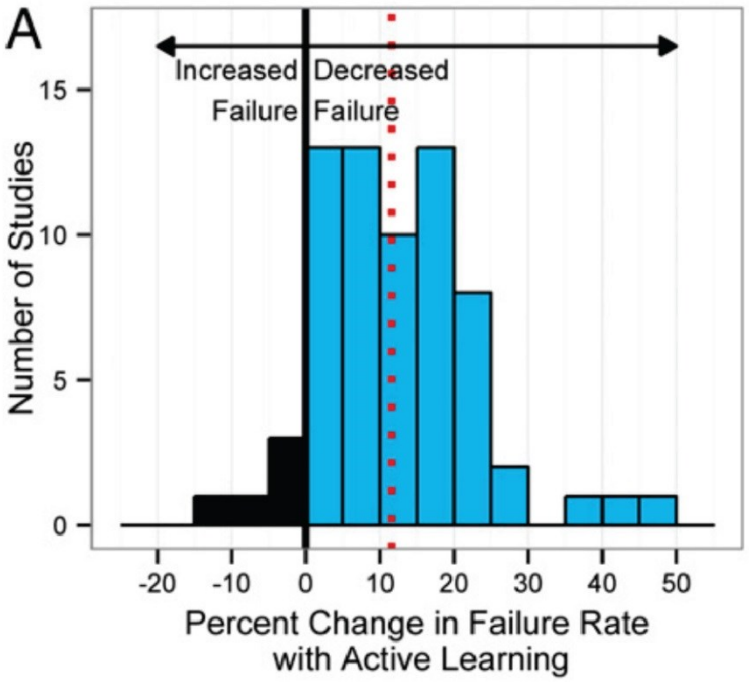
Methods Used in "All" or "Most"	STEM women	STEM men	All other women	All other men
Cooperative learning	60%	41%	72%	53%
Group projects	36%	27%	38%	29%
Grading on a curve	17%	31%	10%	16%
Student inquiry	43%	33%	54%	47%
Extensive lecturing	50%	70%	29%	44%

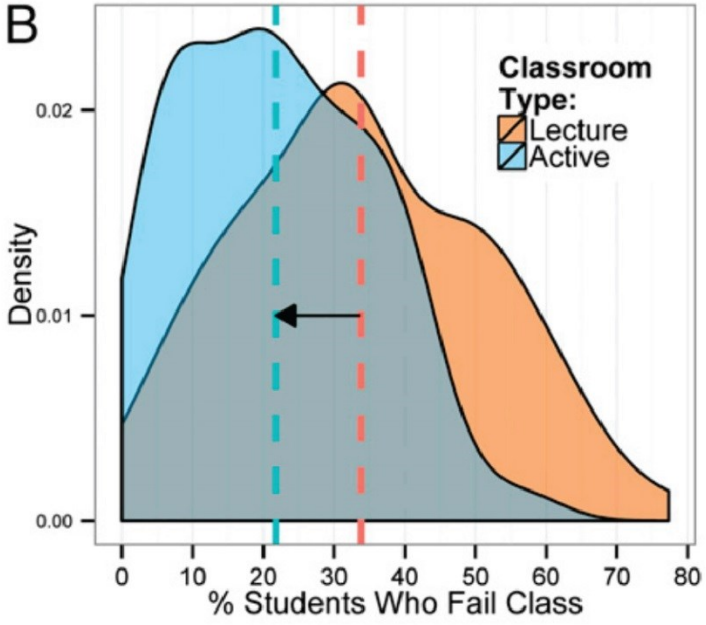
*Undergraduate Teaching Faculty. National Norms for the 2010-2011 HERI Faculty Survey,

www.heri.ucla.edu/index.php

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





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.

Discipline-Based Education Research (DBER) Report

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

LAST WORD — OPINION BY SUSAN SINGER & KARL SMITH

Follow the Evidence

Discipline-based education research dispels myths about learning and yields results – if only educators would use it.

Last year, the National Research Council released the report *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. That consensus study, on which we served as committee members, brought together experts in physics, chemistry, biology, the geosciences, astronomy, and engineering, as well as higher education researchers, learning scientists, and cognitive scientists to focus on how students learn in particular scientific and engineering disciplines. Our key conclusion: Findings from the growing field of discipline-based education research (DBER) have yet to spur widespread changes in the teaching of science and engineering.

For example, research-based instructional approaches to teaching that actively engage students in their own learning, such as group projects, have been shown to be more effective than traditional lectures. Yet science and engineering faculty still cling to familiar practice. While there's no magic solution for adopting evidence-based teaching practices, finding out what is known about undergraduate learning in engineering and science—and identifying impediments to implementation in the classroom—can point the way.

First, many students have incorrect understanding about fundamental concepts—particularly phenomena that are not directly observable, such as those involving very large or small scales of time and space. Understanding how educators can help students change these misconceptions is in the early stages, but DBER has uncovered some effective instructional techniques. One promising approach is to use "bridging analogies" that link students' correct knowledge with the situation about which they harbor false beliefs. For instance, a student may not believe that a table can exert a force on a book resting on its surface but accepts the notion if a spring is placed under the same book. Linking these two ideas, with perhaps an intermediate of a book resting on a foam block, can move the student toward a correct understanding of forces.

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

Students also are challenged by important aspects of engineering and science that can seem easy or obvious to experts. When tackling a problem, for instance, students tend to focus on the superficial rather than on its deep structure. Instructors may have an "expert blind spot" and not recognize how different the student's approach is from their own, which can impede effective instruction. Several strategies appear to improve problem-solving skills, such as providing support and prompts—known as "scaffolding"—as students work their way through problems. Another common issue for students in all disciplines is difficulty in extracting information from graphs, models, and simulations. Using multiple representations in instruction is one way to move students toward expertise.

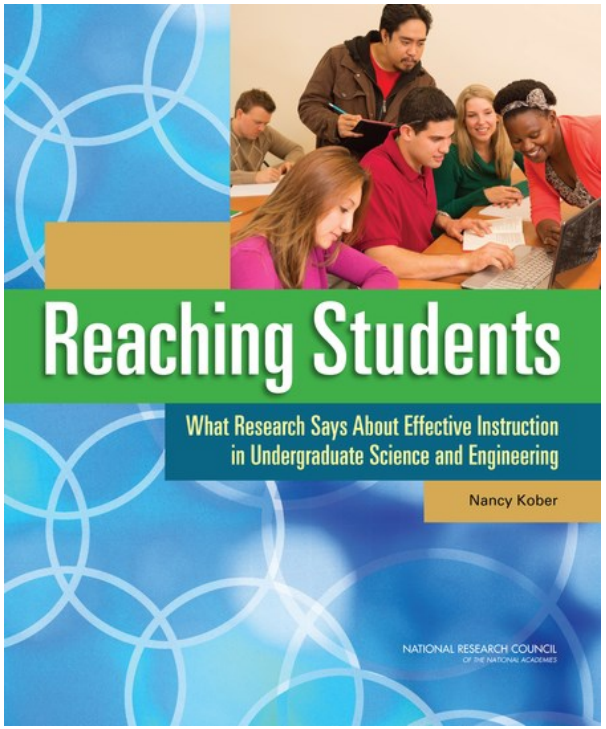
The report recommends future DBER research that explores similarities and differences in learning among various student populations, and longitudinal studies that shed additional light on how students acquire and retain an understanding (or misunderstanding) of concepts. However, we also need strategies that translate the findings of DBER and related research into practice. That includes finding ways around barriers, such as the faculty reward system, the relative value placed on teaching versus research, lack of support for faculty learning to use research-based practices, problems with student evaluations, and workload concerns.

The report urges universities, disciplinary organizations, and professional societies to support faculty efforts to use evidence-based teaching strategies in their classrooms. It also recommends collaboration to prepare future faculty members who understand research findings on learning and teaching and who value effective teaching as part of their career aspirations. By implementing these recommendations, engineering and science educators will make a major first step toward using DBER to improve their practice—and learning outcomes.

Susan Singer, the Laurance McKinley Gould Professor of the Natural Sciences at Carleton College, chaired the National Research Council committee that prepared the consensus study. Karl Smith, the Cooperative Learning Professor at Purdue University's School of Engineering Education and emeritus professor of civil engineering at the University of Minnesota, represented engineering on the committee. To view the report, visit http://www.nap.edu/

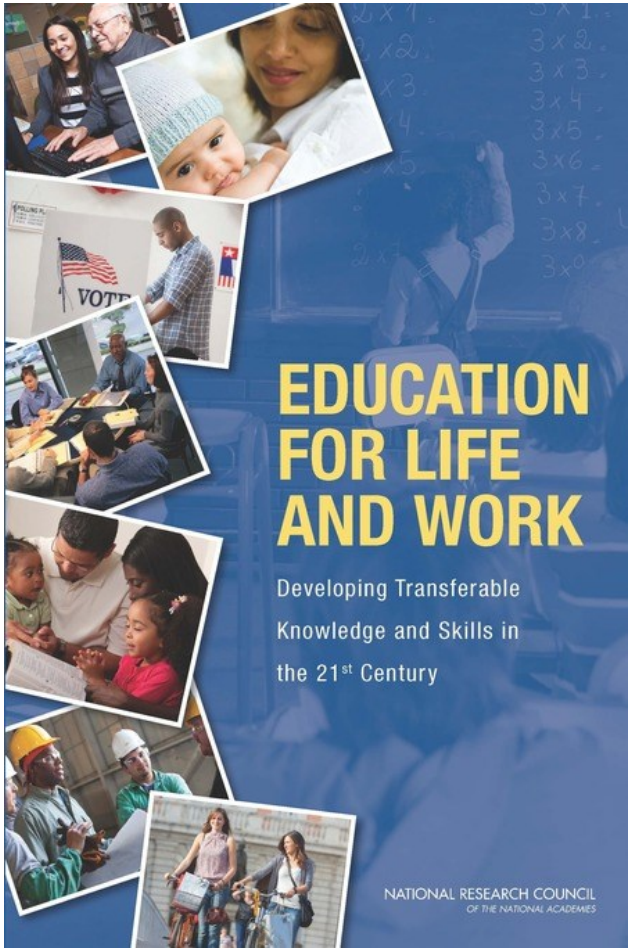
ASEE *Prism Summer 2013*

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

Education for Life and Work



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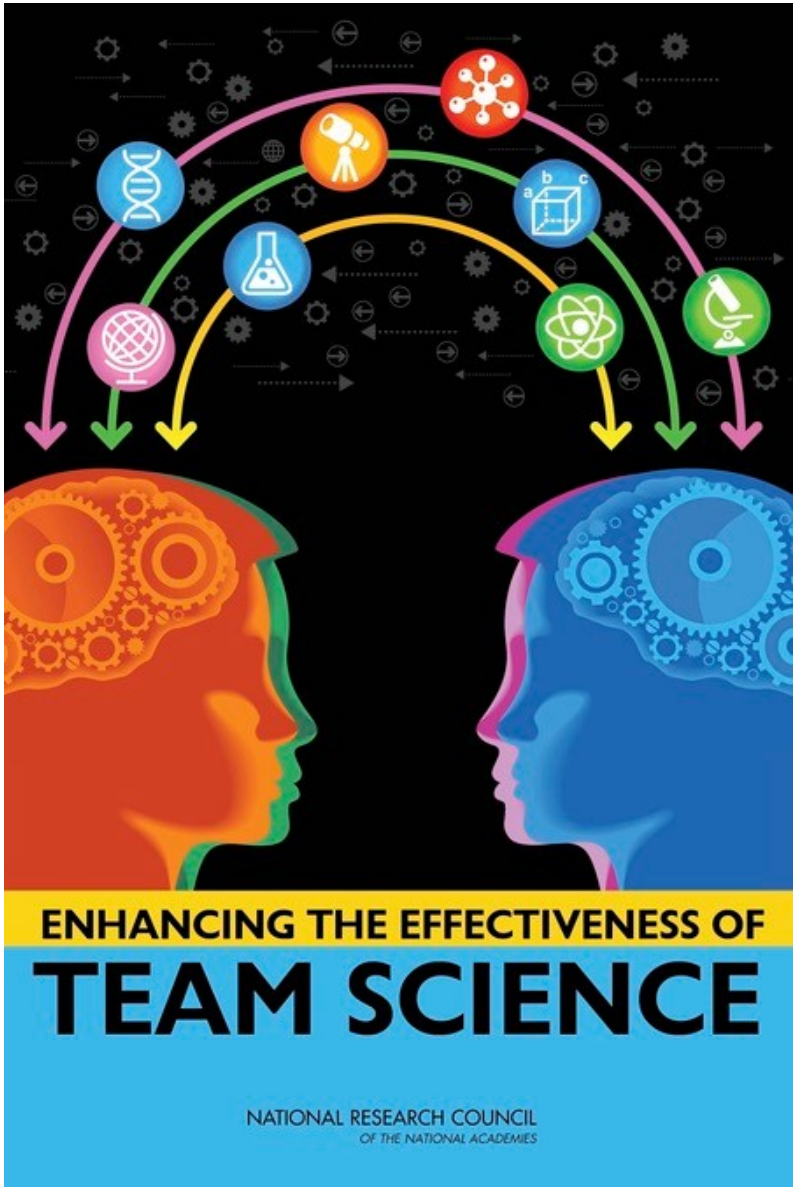
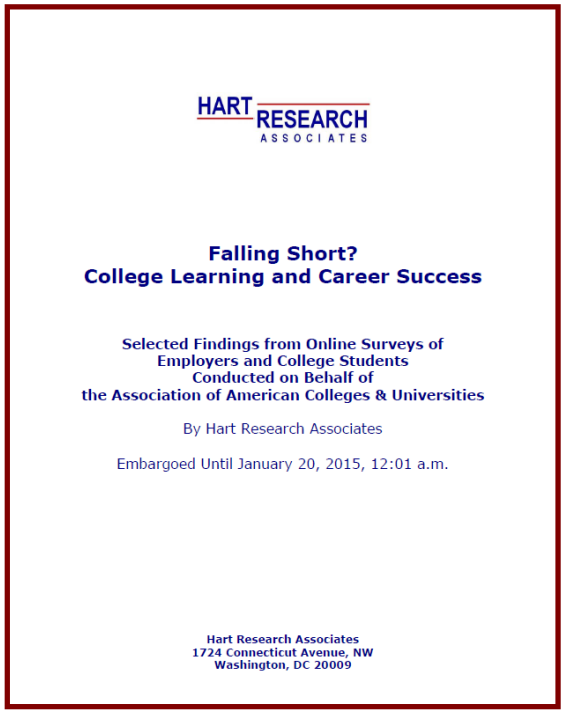
2. A Preliminary Classification of Skills and Abilities 21
3. Importance of Deeper Learning and 21st Century Skills 37
4. Perspectives on Deeper Learning 69
5. Deeper Learning of English Language Arts, Mathematics, and Science 101
6. Teaching and Assessing for Transfer 143
7. Systems to Support Deeper Learning 185

http://www.nap.edu/catalog/13398/education-for-life-and-work-developing-transferable-knowledge-and20 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



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

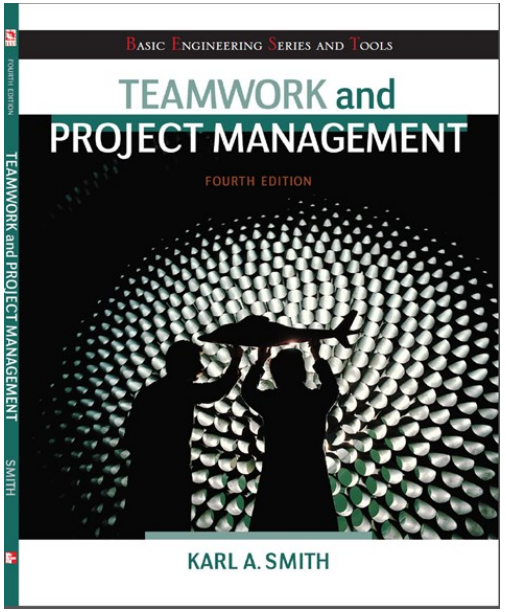
Top Three Main Engineering Work Activities

Engineering Total

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

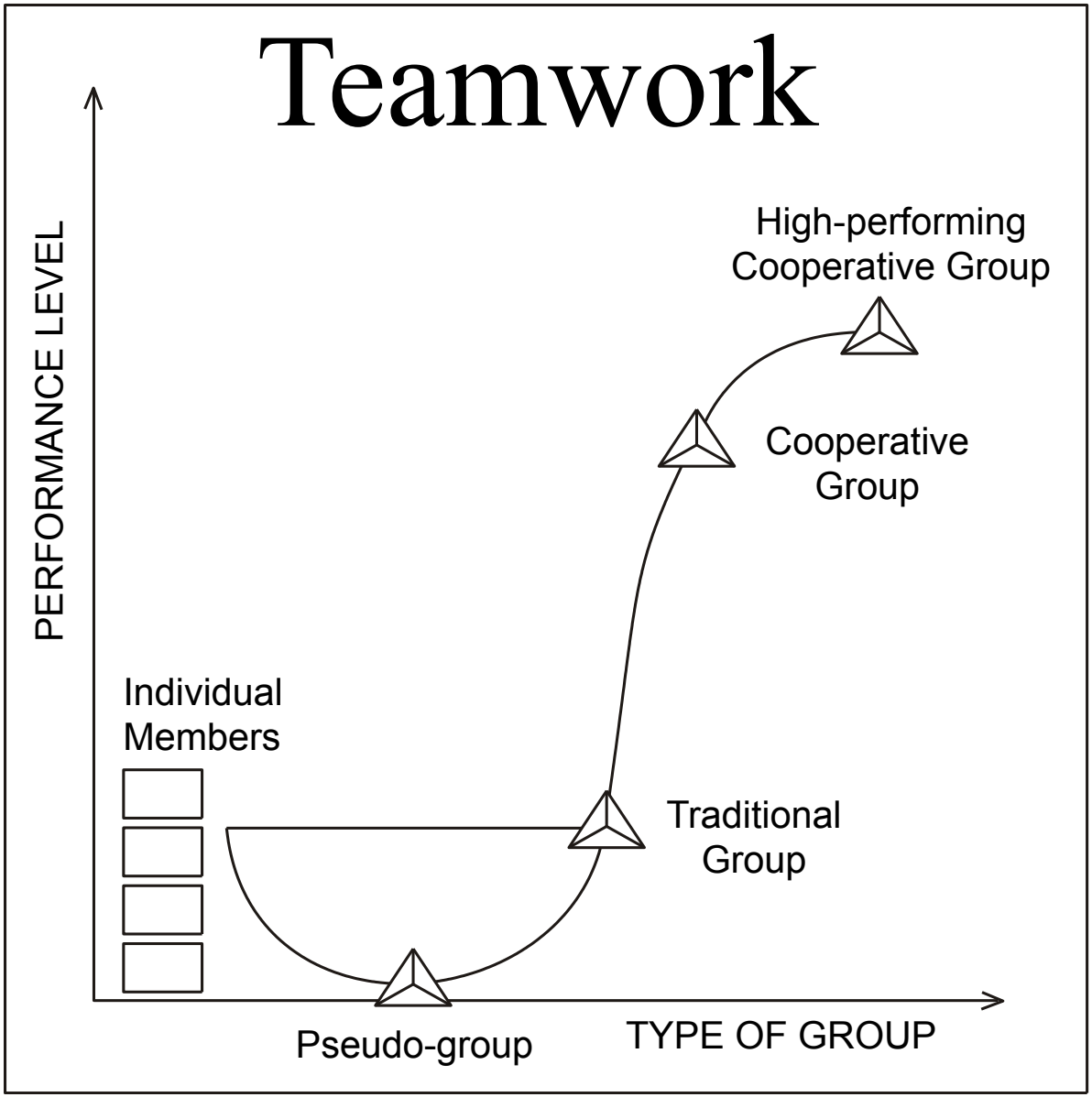
Civil/Architectural

- 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.

Teamwork


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

Reflection and Dialogue

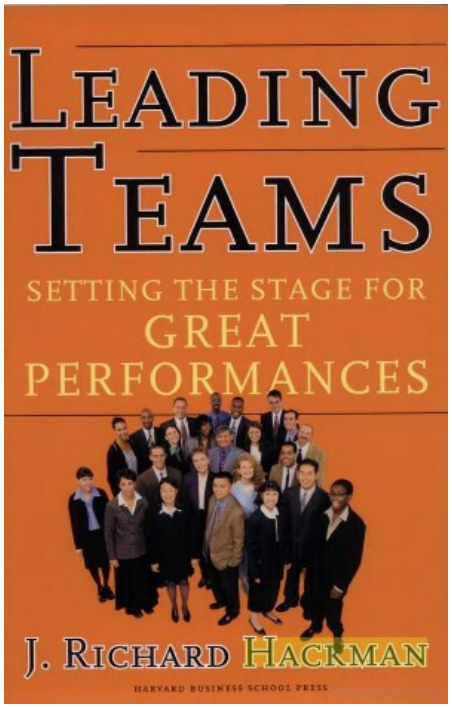
- Individually reflect on the Characteristics of High Performing Teams. Think/Write for about 1 minute
  - Based on your experience on high performing teams,
  - Or your facilitation of high performing teams in your organization
  - Or your observation of high performing teams
  - Or your imagination
- Discuss with your neighbors for about 2 minutes and record a list

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

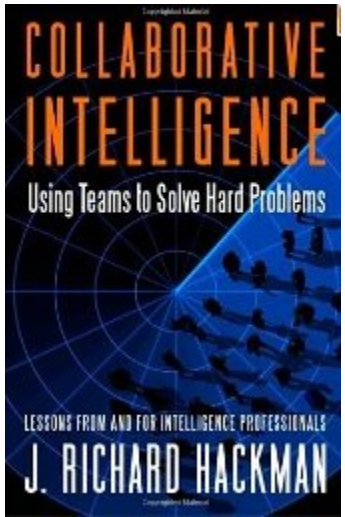
- SMALL NUMBER
- COMPLEMENTARY SKILLS
- COMMON PURPOSE & PERFORMANCE GOALS
- COMMON APPROACH
- MUTUAL ACCOUNTABILITY

--Katzenbach & Smith (1993)
The Wisdom of Teams

Hackman – Leading Teams



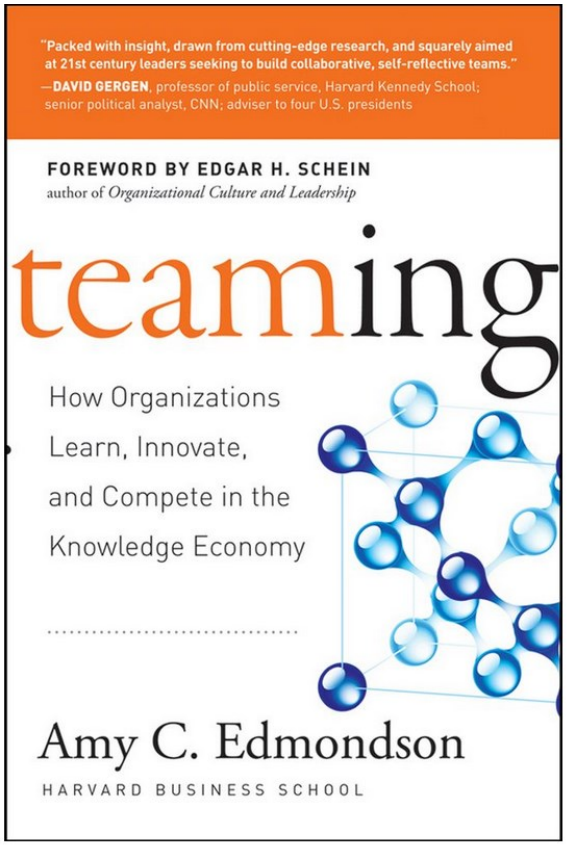
- Real Team
- Compelling Direction
- Enabling Structure
- Supportive Organizational Context
- Available Expert Coaching



Team Diagnostic Survey (TDS)

https://research.wjh.harvard.edu/TDS/

Edmondson - *Teaming*



"Teaming is the engine of organizational learning."

- Learning to team, teaming to learn
- Teaming process (bottom-up)
  - Teaming mindset adopted
  - Reflection/feedback
  - Interdependent action unfolds
  - Coordination of steps and hand-offs
  - Individuals communicate
  - Recognize need for teaming
- Four pillars of effective teaming
  - Speaking up
  - Collaboration
  - Experimentation
  - Reflection

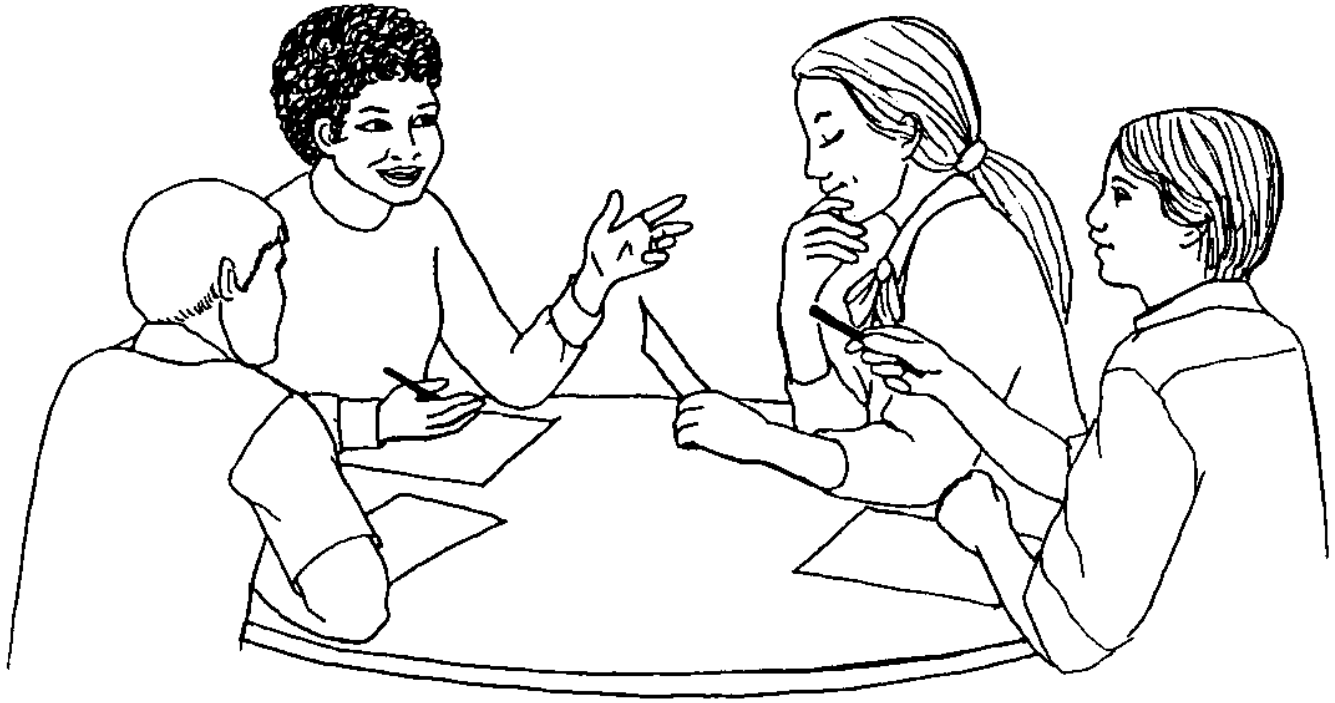
The most valuable form of communication is face-to-face. E-mail and texting are least valuable. Pentland (2012)

Successful teams share several defining characteristics:

1. Everyone on the team talks and listens in roughly equal measure, keeping communication short and sweet.
2. Members face one another, and their conversations and gestures are energetic.
3. Members connect directly with one another – not just with the team leader
4. Members carry on back-channel or side conversations.
5. Members periodically break, go exploring outside the team, and bring information back.

https://hbr.org/2012/04/the-new-science-of-building-great-teams

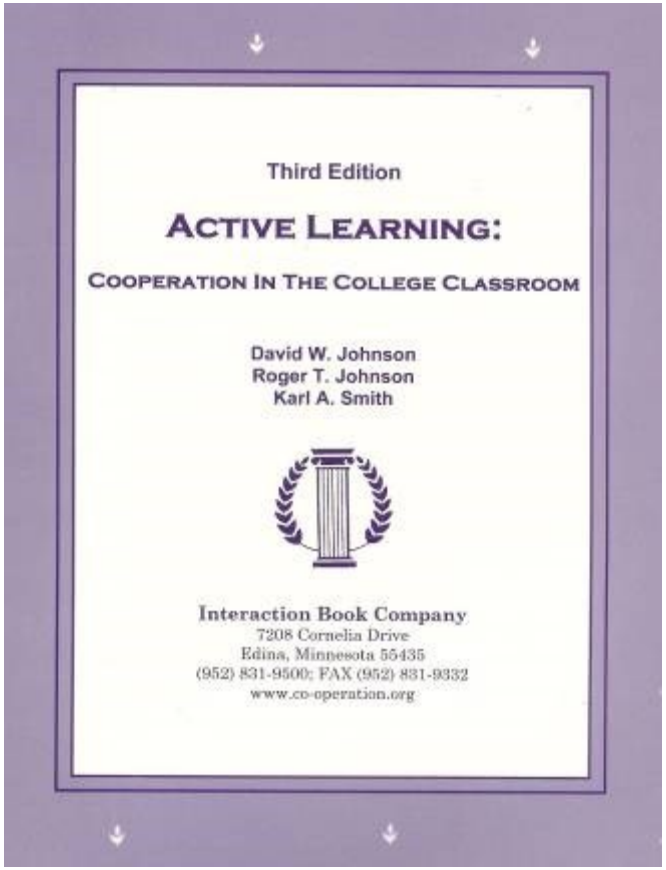
Structuring Teamwork in the Classroom



Formal Cooperative Learning Task Groups

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]

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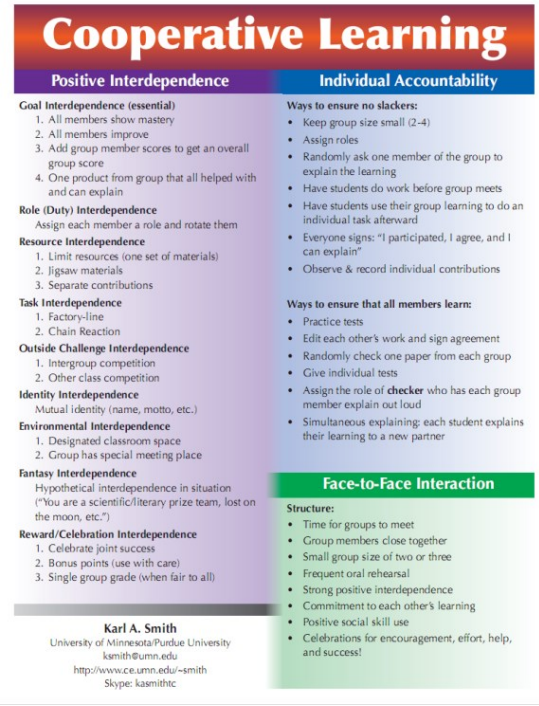

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- Celebrations for encouragement, effort, help, and success!

Instructor's Role in Formal Cooperative Learning

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

2. Making **Decisions**

3. Explaining **Task**, **Positive Interdependence**, and **Individual Accountability**

4. **Monitoring** and Intervening to Teach Skills

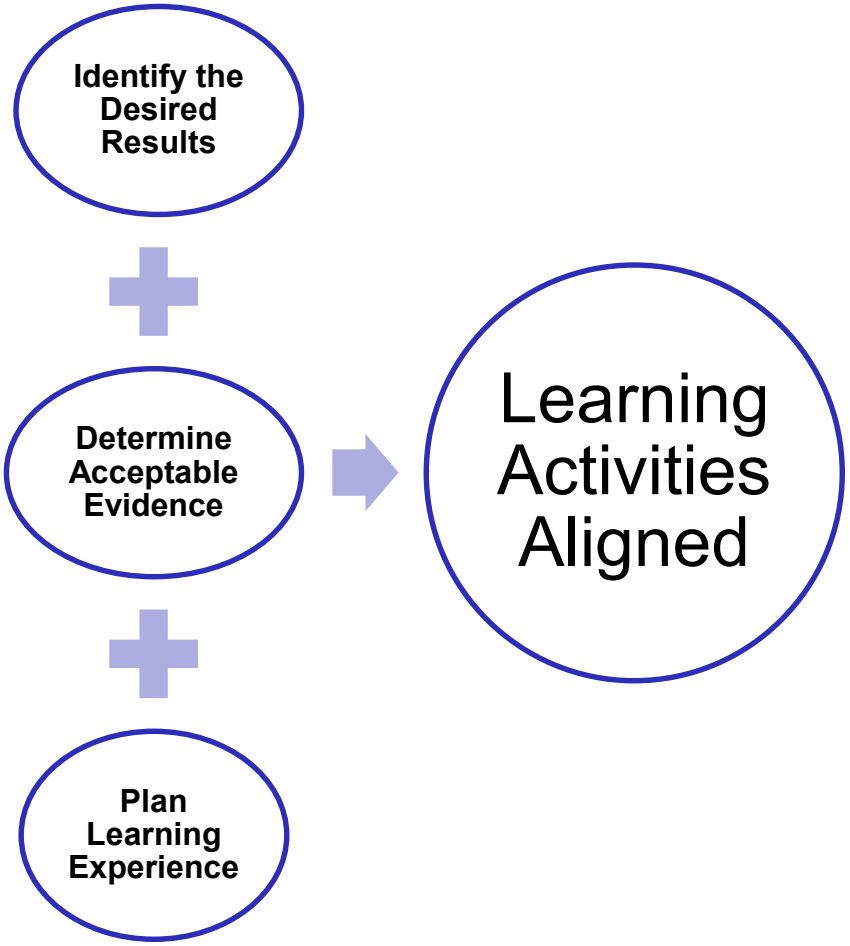
5. **Evaluating** Students' Achievement and Group Effectiveness

Understanding by Design Process

What should learners know, understand and be able to do?

How will we know if the learners have achieved the desired results?
What will be accepted as evidence of learners' understanding and proficiency?

What activities will equip learners with the needed knowledge and skills?
What materials and resources will be useful?



-Understanding by Design,
Wiggins and McTighe (1998)

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?

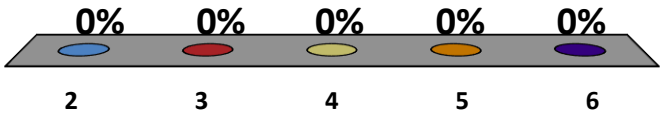
A. 2

B. 3

C. 4

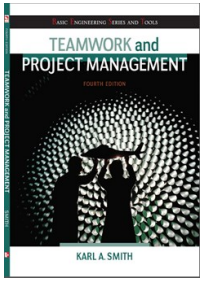
D. 5

E. 6



Formal Cooperative Learning Task Groups

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



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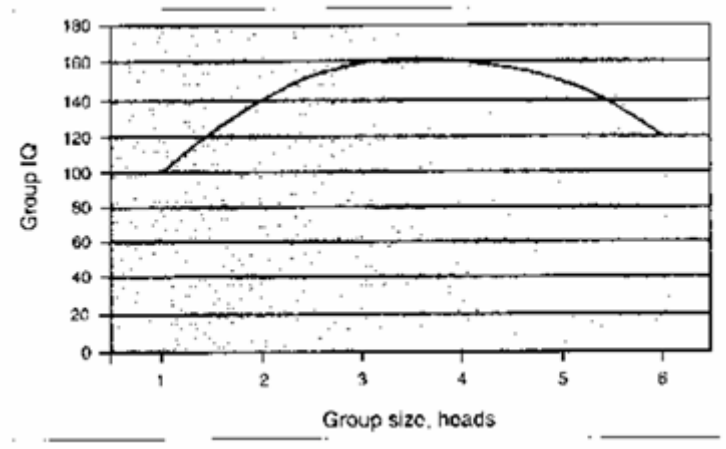
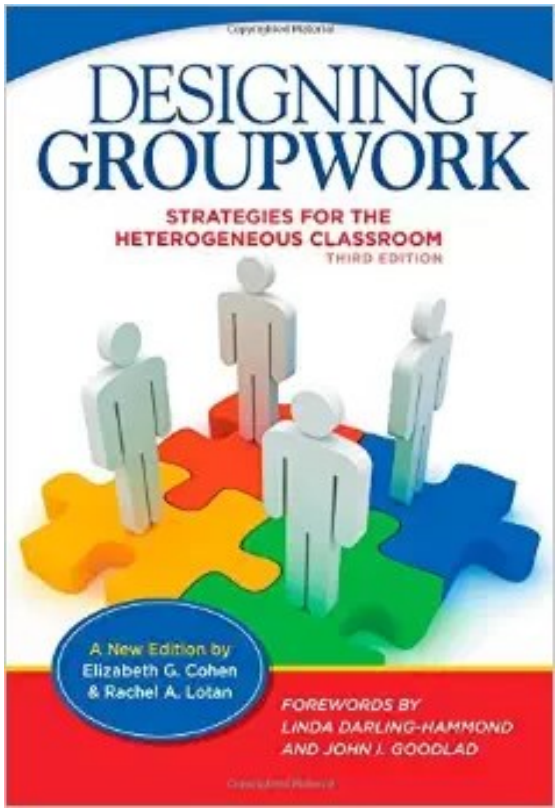


Group Selection?

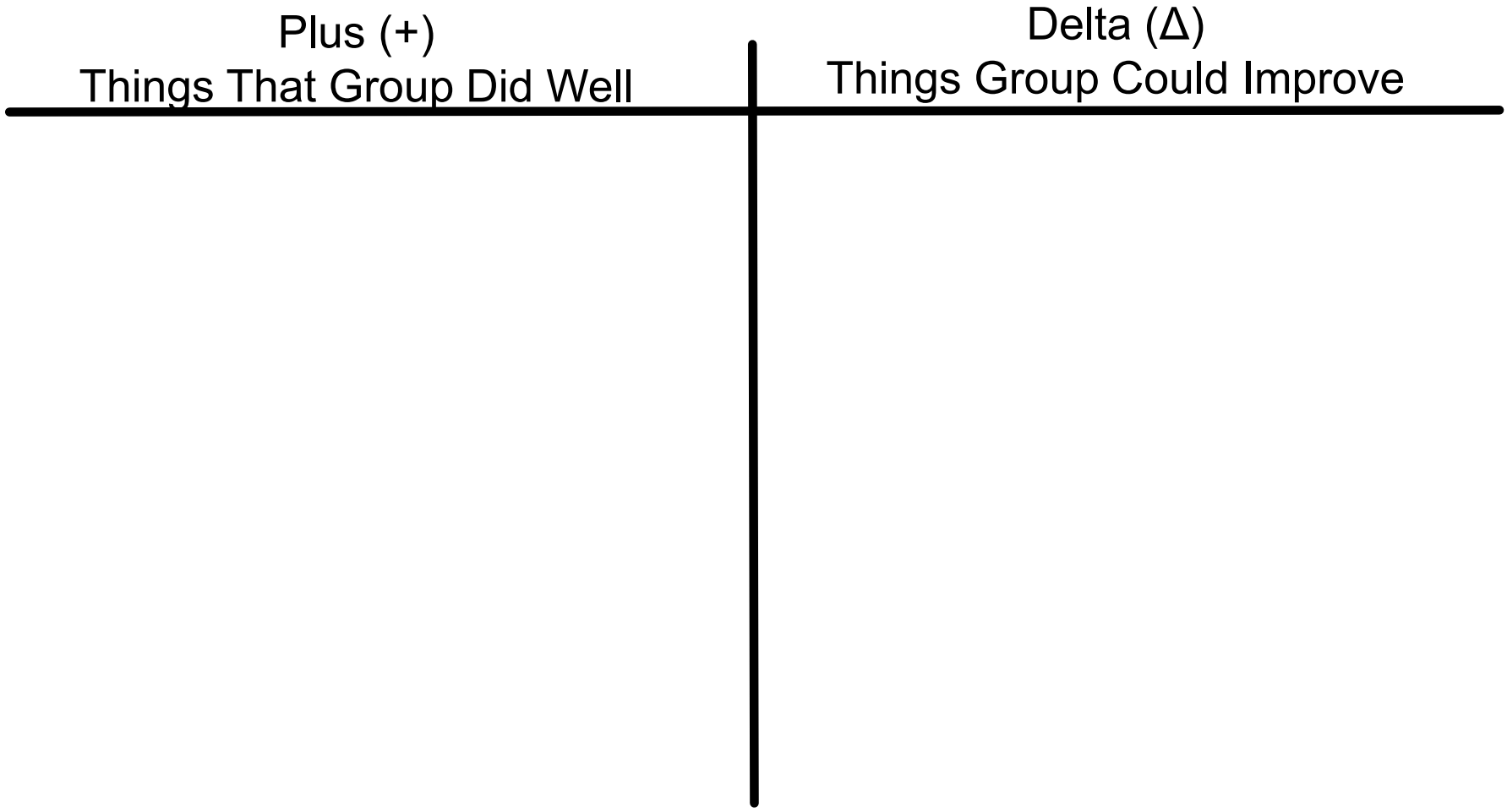
A. Self selection
B. Random selection
C. Stratified random
D. Instructor assign
E. Other

Assigning Roles



- Chapter 8: Group Roles and Responsibilities
  - How roles
    - Facilitator
    - Checker
    - Set-Up
    - Materials Manager
    - Safety Officer
    - Reporter
  - Dividing the labor

Group Processing
Plus/Delta Format



Formal Cooperative Learning – Types of Tasks

1. **Problem Solving, Project, or Presentation**
2. **Jigsaw – Learning new conceptual/procedural material**
3. **Group Tests**
4. Review/Correct Homework
5. Peer Composition or Editing
6. Reading Comprehension/Interpretation
7. Constructive Controversy

Challenge-Based Learning

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

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

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

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.

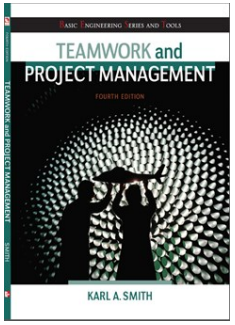
INDIVIDUAL ACCOUNTABILITY: One member from your group may be randomly chosen to explain (a) the answer and (b) how to solve each problem.

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

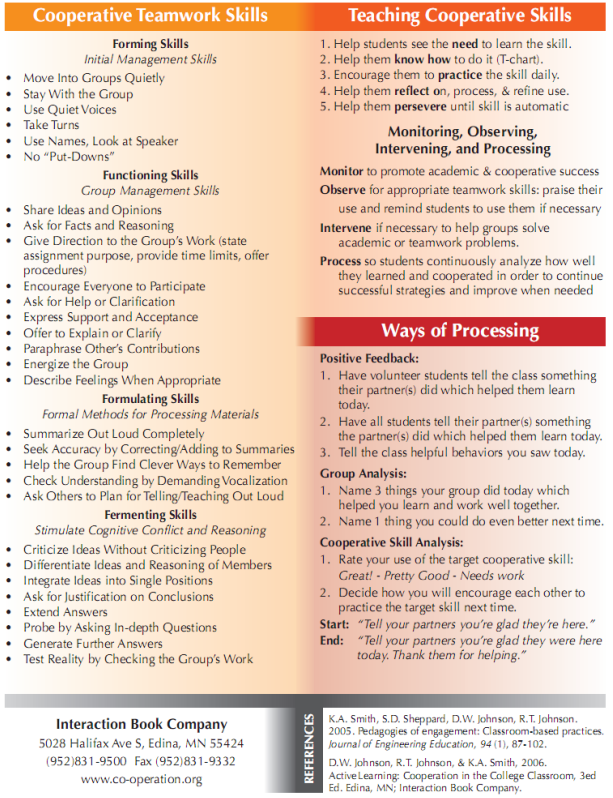
INTERGROUP COOPERATION: Whenever it is helpful, check procedures, answers, and strategies with another group.

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 o**n, 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

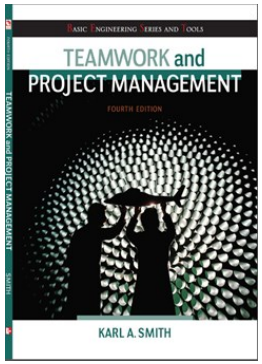
REFERENCES

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, 3ed Ed. Edina, MN; Interaction Book Company.

Team Charter

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



pp. 60-61, 204-20

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._____

PROJECT TEAM CONTRACT	
Project Name:	
Team Members:	

Our Agreement

- We all promise to listen to each other's ideas with respect.
- We all promise to do our work as best as we can.
- We all promise to do our work on time.
- We all promise to ask for help if we need it.
- We all promise to _____

If someone on our team breaks one or more of our rules, the team may have a meeting and ask the person to follow our agreement. If the person still breaks the rules, we will ask our teacher to help find a solution.

Date: _____

Team Member Signatures:

_____ _____

_____ _____

_____ _____

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: _____

Designing and Implementing Cooperative Learning

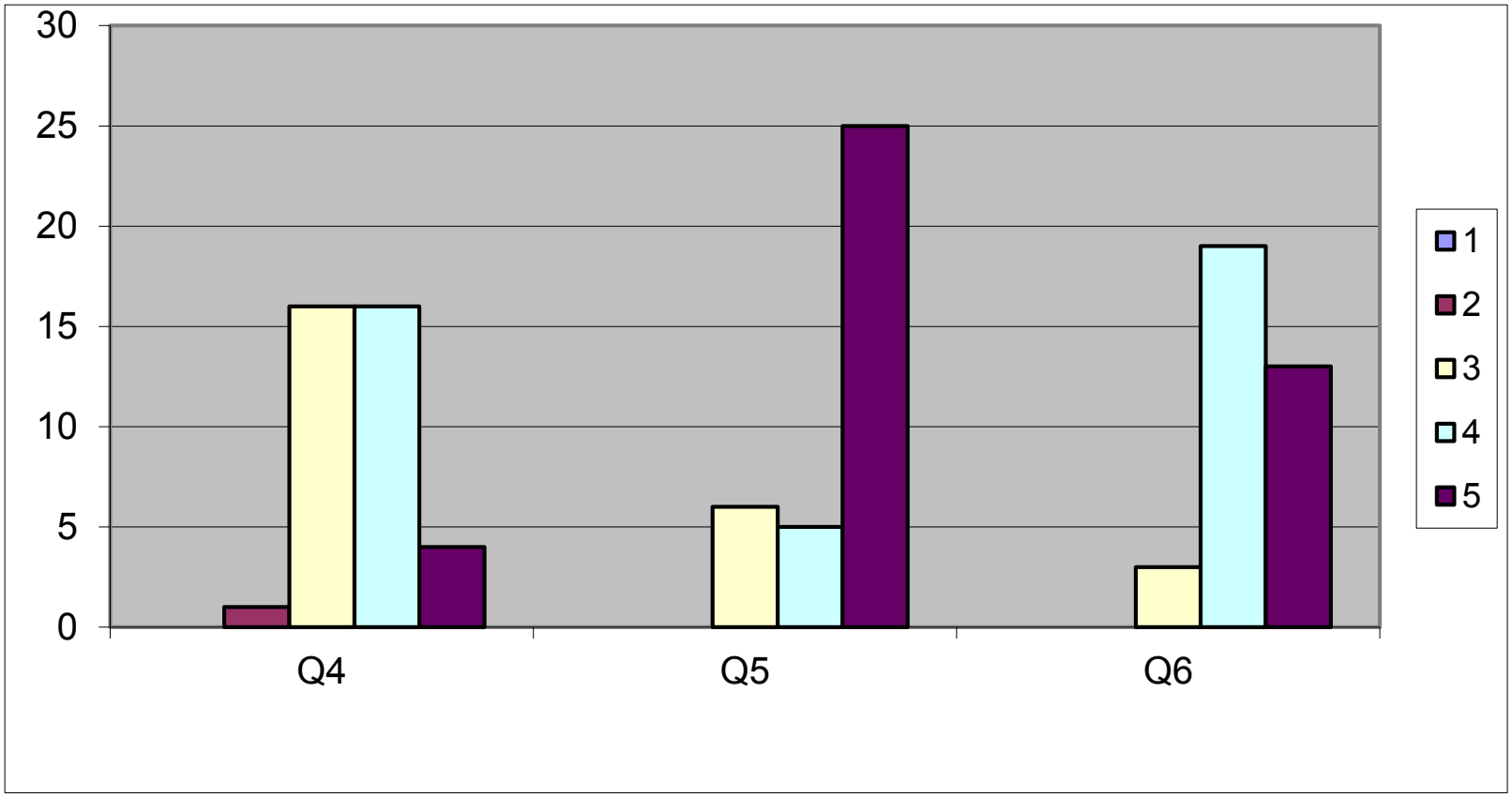
- Think like a designer
- Ground practice in robust theoretical framework
- Start small, start early and iterate
- Celebrate the successes; problem-solve the failures

Session Summary (Minute Paper)

Reflect on the session

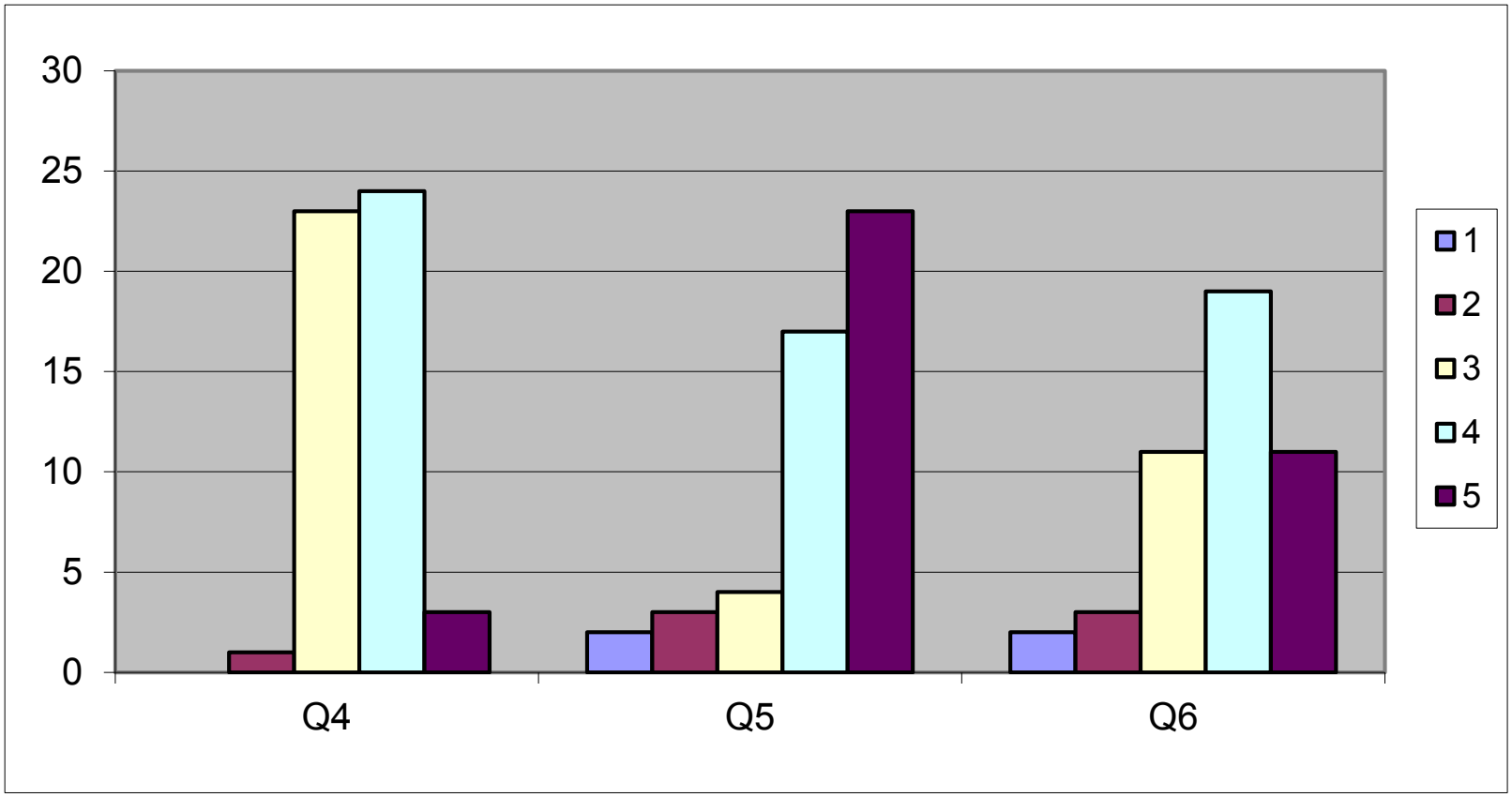
1. Most interesting, valuable, useful thing you learned?
2. Any surprises?
3. Questions, comments, suggestions.
4. Pace: Too slow 1 2 3 4 5 Too fast
5. Relevance: Little 1 2 3 4 5 Lots
6. Instructional Format: Ugh 1 2 3 4 5 Ah

AAPT – Teamwork Session (7-28-15)



Q4 – Pace: Too slow 1 . . . . 5 Too fast (3.6)
Q5 – Relevance: Little 1 . . . 5 Lots (4.5)
Q6 – Format: Ugh 1 . . . 5 Ah (4.3)

EngrTEAMS – Team Charter Session (7-1-15 am)



Q4 – Pace: Too slow 1 . . . . 5 Too fast (3.6)
Q5 – Relevance: Little 1 . . . 5 Lots (4.1)
Q6 – Format: Ugh 1 . . . 5 Ah (3.7)