Fulton Schools of Engineering Education Seminars (SEEdS)

FSE Learning and Teaching Hub
fse-lthub@asu.edu
February 21, 2025

Ira A. Fulton Schools of Engineering
Arizona State University

Agenda

- **Welcome + Hub opportunities**
- **Seminar: Design and Implementation of Interactive Learning** with guest speakers Karl Smith and Kristen Peña
- **Questions and Discussion**

Welcome!

- Thank you for joining us!
- **Recording:** Our seminar presentations will be posted on our YouTube channel.
- **Zoom:** Please continue to use the chat and unmute during the discussion.
- **Resource Folder:** **links.asu.edu/FultonSEEdS**

Upcoming opportunities

Fulton Schools of Engineering Education Seminars (SEEdS)

Third Fridays | 12pm-1pm MST | Zoom

Today! February 21, 2025: Pedagogy of Engagement: Design and Implementation of Cooperative, Interactive Learning with guest speakers Karl Smith (University of Minnesota) and Kristen Peña (ASU)

March 21, 2025: Learning Analytics with guest speaker Tim McKay (University of Michigan)

April 18, 2025: Engineering Ethics with guest speaker Michael Loui (University of Illinois)

links.asu.edu/FultonSEEdS

Communities of Practice

- Generative AI in Teaching and Learning
- Inclusive Learning Environments
- Learning Communities
- LTH Book Study
- Mastery-Based Learning
- Meaningful Learning with Multimedia
- Scalable Classroom Assessments in Large Enrollments (SCALE)
- Scholarship of Teaching and Learning (SoTL) and Entrepreneurial Mindset (EM)

PL Calendar

Cohort of Recently-hired Educators (CORE)

Designed to offer actionable instructional ideas specific to teaching and learning in engineering courses. Two monthly options will be offered.

Coming up!

Embracing and Integrating the Entrepreneurial Mindset

Guest speaker: **Doug Melton**

Tuesday, Feb. 25 | 2pm - 3pm

or

Wednesday, Feb. 26 | 1pm - 2pm

Other ways to engage with the Hub

Connect

Sign up for our newsletter

Connect with a LTH Faculty Coaches

Follow us on LinkedIn

Engage

Meet with **Learning Experience Designers** and **Instructional Innovation Coaches**

Schedule a conversation at: **fse-lthub@asu.edu**

Explore

Quick-reference guides, media studios, and more:

lth.engineering.asu.edu

Watch past SEEdS seminars on YouTube

Design and Implementation of Interactive Learning

Fostering engagement and collaboration in the classroom is more critical than ever. This seminar explores the Pedagogy of Engagement, focusing on the transformative impact of cooperative and interactive learning. Framed by major shifts in engineering education and principles of how learning works, the session will delve into cooperative learning strategies—informal, formal, and base groups—and highlight evidence-based practices that foster student collaboration and deeper learning.

ASU Ira A. Fulton Schools of Engineering
Arizona State University

Karl A. Smith is Emeritus Cooperative Learning Professor of Engineering Education, School of Engineering Education, at Purdue University. He is also Emeritus Professor of Civil, Environmental, and Geo- Engineering, Morse-Alumni Distinguished University Teaching Professor, and Faculty Member, Technological Leadership Institute at the University of Minnesota. He joined the University of Minnesota in 1972 and started his academic career as a materials processing engineering researcher. In 1991 he changed careers to focus on engineering education research and in 2006 he accepted a part time position as Cooperative Learning Professor, School of Engineering Education, Purdue University to help start the engineering education PhD program in the College of Engineering. His research and development interests include building research and innovation capabilities in engineering education; faculty and graduate student professional development; and the role of cooperation in learning and design.
Karl has over 40 years of experience working with faculty to redesign their courses and programs to improve student learning. He adapted the cooperative learning model to engineering education and has helped many faculty and graduate students with implementation. He wrote or co-wrote eight books including How to model it: Problem solving for the computer age, Cooperative learning: Increasing college faculty instructional productivity, New paradigms for college teaching, Strategies for energizing large classes: From small groups to learning communities, Active learning: Cooperation in the college classroom, and Teamwork and project management. His bachelor's and master's degrees are in metallurgical engineering from Michigan Technological University and his Ph.D. is in educational psychology from the University of Minnesota.

Kristen Peña serves as the Senior Program Manager, Learning Initiatives at the Fulton Schools of Engineering (FSE) Learning & Teaching Hub (LTH). In this role, she leads the planning, development, and delivery of faculty professional learning programs, including communities of practice, workshops, quick-reference guides, and other resources designed to support engineering instructional staff and faculty.

Peña has held various positions in higher education, focusing on student development, faculty-directed initiatives, and entrepreneurial experiential learning. As a first-generation college graduate, she earned her Doctor of Education in Leadership and Innovation from Arizona State University (ASU).

Her research interests center on faculty professional development, faculty-student interactions, first-generation college student experiences, and strategies for retaining students in STEM fields.

Design and Implementation of Interactive Learning

Karl A. Smith
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Civil, Environmental, and Geo- Engineering –
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Session Layout

BIG IDEAS

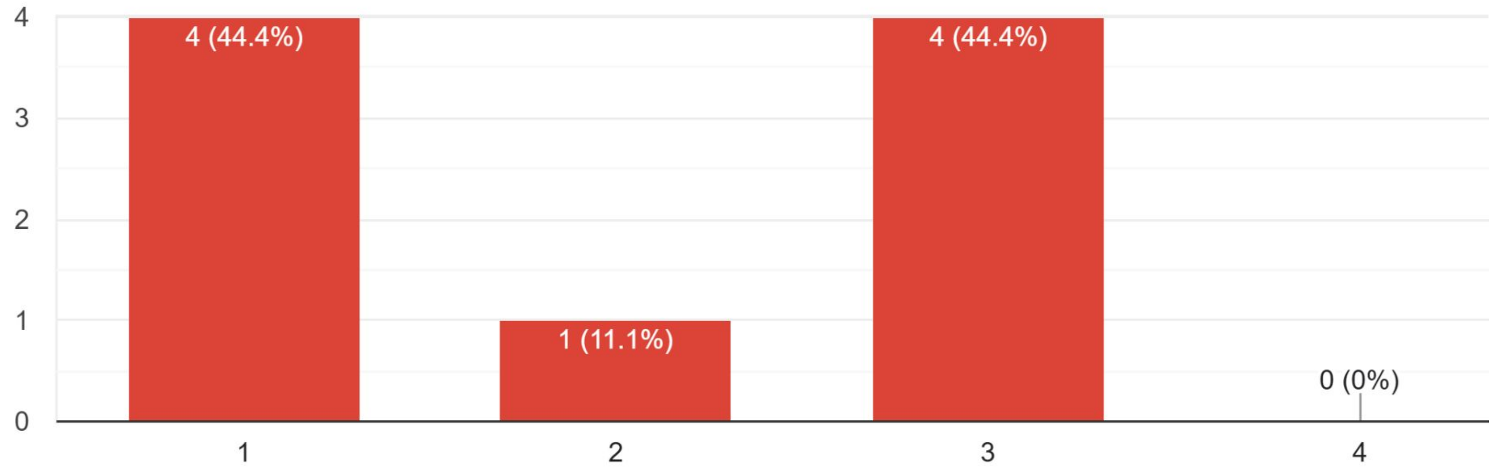
- Major Shifts in Engineering Education
- How Learning Works
- Alignment of Outcomes, Assessment and Instruction

Interactive (Cooperative) Learning

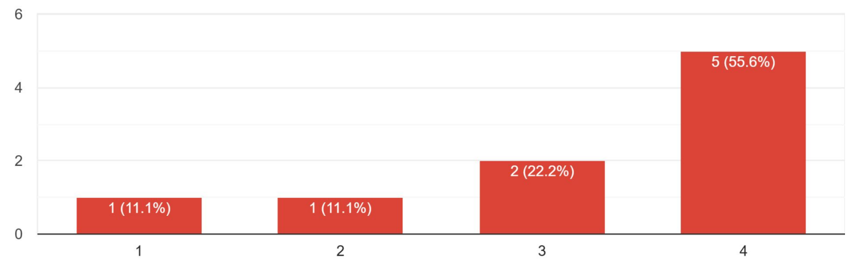
- Definitions and Research
- Types of Cooperative Learning

Pre-workshop Survey

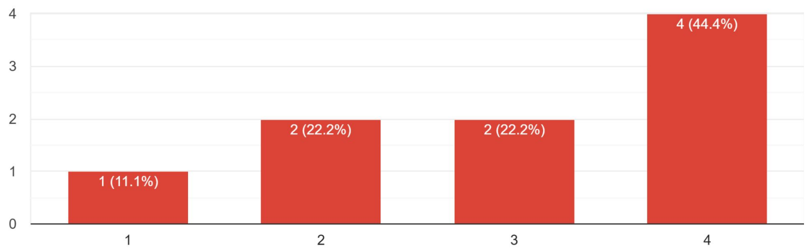
Please note your level of awareness/understanding of the following - Neuroscience of Learning (How People Learn)
9 responses



Please note your level of awareness/understanding of the following - Aligning student learning outcomes, assessment strategies, and instruction
9 responses

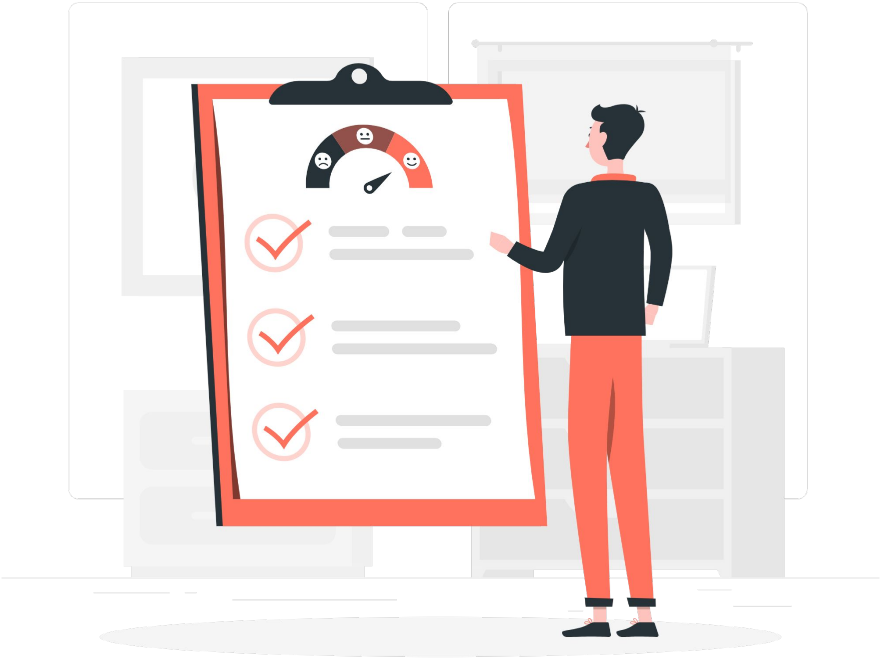


Please note your level of awareness/understanding of the following - Design and implementation of interactive learning (e.g., Cooperative Learning, Problem/Project-based Learning, Peer Led Study Group)
9 responses



Pre-workshop Survey: What do you want to get out of the session?

- ***New strategies*** *to improve/support learning for* ***today's generation*** *of students, connections between* ***mental health and learning****, how to rewire the brain for learning.* ***FUN!!***
- *How do we promote interactive learning in* ***online modalities or large enrollment settings.***
- ***Learn more*** *about the above topics.*



Major Shifts in Engineering Education

- Engineering science
- Outcomes and accreditation
- Engineering design
- Social-behavioral sciences
- ICC technologies

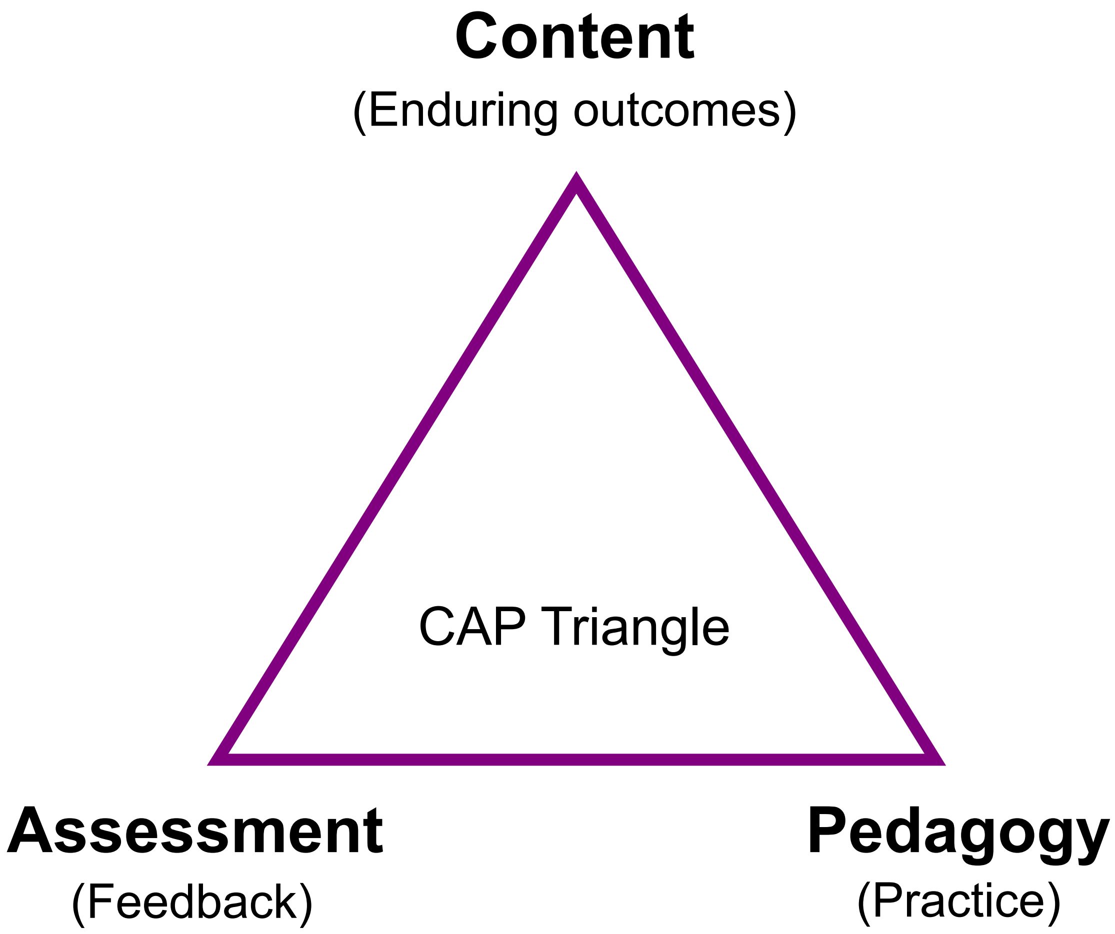
Five Major Shifts in 100 Years of Engineering Education

By Jeffrey E. Froyd, *Fellow IEEE*, Phillip C. Wankat, and Karl A. Smith

Proceedings of the IEEE (Volume: 100, Issue: Special Centennial Issue, 13 May 2012)
https://ieeexplore.ieee.org/abstract/document/6185632

Major Shifts in Engineering Education National Academy of Engineering Practices for Engineering Education and Research (PEER) Program Guidance Group – August 14, 2024

Outcomes-based Education and Accreditation

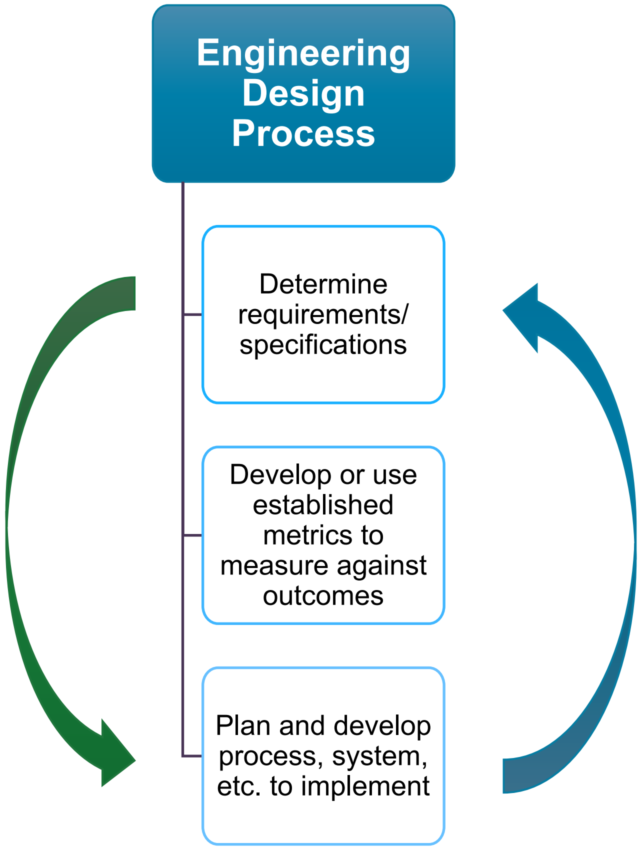


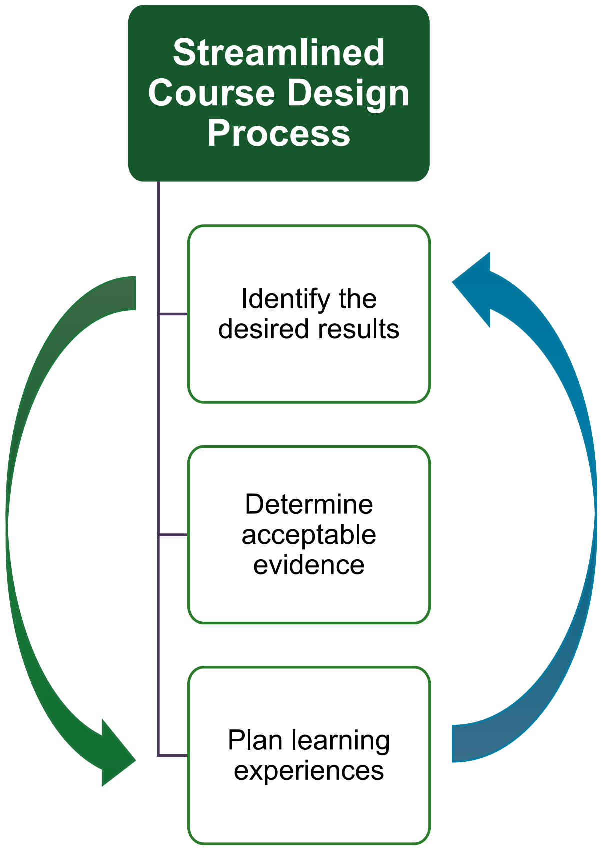
IMPLICATION:

Identifying and articulating enduring outcomes is a critical part of effective course design.

See: Streveler & Smith (2020)

Emphasis on Engineering Design





IMPLICATION:

Embracing the engineering design process for course design makes sense.

https://advances.asee.org/opinion-course-design-in-the-time-of-coronavirus-put-on-your-designers-cap/

James Duderstadt
Nuclear Engineering Professor
Former Dean, Provost and President
University of Michigan

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

Shifts in Engineering Education: Implications

Engineering Science

Theory and research matter.

Outcomes Accreditation

Identifying and articulating enduring outcomes is a critical part of effective course design.

Engineering Design

Embracing the engineering design process for course design makes sense.

Social Sciences

Applying what we know about learning is essential:

Cognitive Domain
Affective Domain

ICC Technologies

Technology provides affordances to mediate learning—but education is a human activity.

PRIOR SHIFTS

Remote Learning

Engineering teaching and learning can be accomplished remotely—but there are challenges.

Justice, Equity, D&I

Working towards creating and maintaining equitable and inclusive learning environments is imperative.

EMERGING SHIFTS

Education, Learning and Social-Behavioral Sciences

How People Learn

Interactive Learning

Personal and Academic Support

Psychological Safety

IMPLICATIONS:

Applying what we know about learning is essential:

Cognitive Domain

Affective Domain

Education, Learning and Social-Behavioral Sciences

How People Learn

Interactive Learning

IMPLICATIONS:

Applying what we know about learning is essential:

Cognitive Domain

Learning Requires…

Deliberate	Distributed	Practice
▪ Cognitive load (bandwidth) ▪ Reflection ▪ Processing	▪ Repetition over time ▪ Multiple input modes	▪ Attentive ▪ Constructive ▪ Interactive

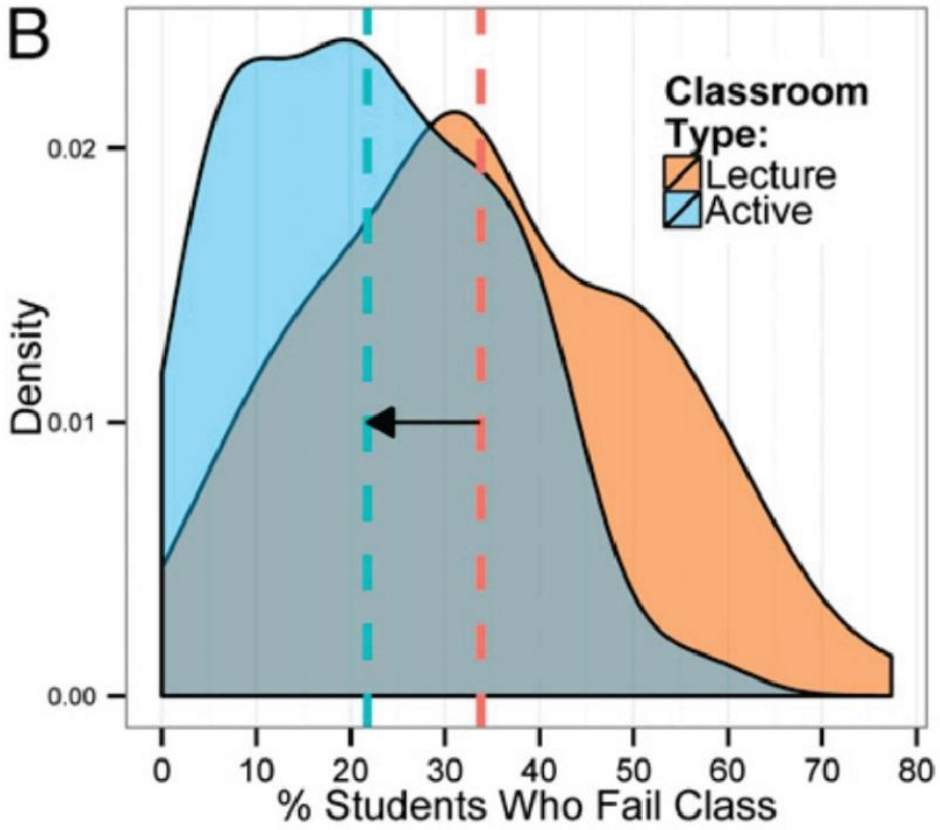
I-C-A-P Framework

Interactive	> Constructive	> Attentive ~~(Active)~~	> Passive
Substantive dialogue on the same topic, not ignoring a partner's contribution	Producing outcomes that go beyond presented information	Doing something physically Paying attention	
Guided-construction	Self-construction	Engaging activities	
Joint creation processes	Creation processes	Attending processes	

See: Chi (2009)

Engaged Pedagogies = Reduced Failure Rate

Reduces Failure Rates



See: Freeman, et.al. (2014)

Education, Learning and Social-Behavioral Sciences

Personal and Academic Support

Psychological Safety

IMPLICATIONS:

Applying what we know about learning is essential:

Affective Domain

Student Support is Essential

Academic Support

Classmates and faculty:

Help students succeed academically.

Personal Support

Classmates and faculty:

Care about and are personally committed to the **well-being** of each student.

The greater the social support,
the greater the academic challenges may be.

Small Group Discussion: Your Experiences with Interactive Learning

Question: What was your experience **as an undergraduate student** with interactive learning?

- First time you heard the term in a class setting *or* the first time you were asked to work with others in a class setting
- What did the instructor ask you to do?
- What rationale did the instructor provide?

In groups of 2-3, discuss for 3 minutes. Once you come back, take a moment to post your groups takeaway from your discussion in the chat.

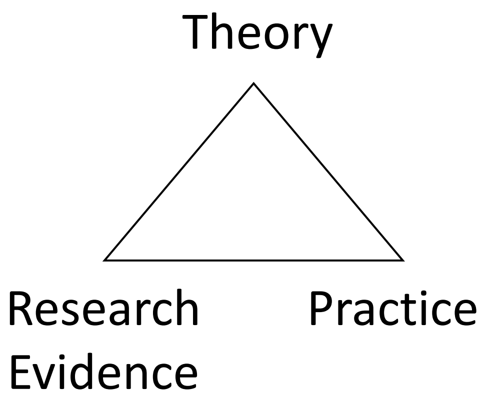
Lila M. Smith

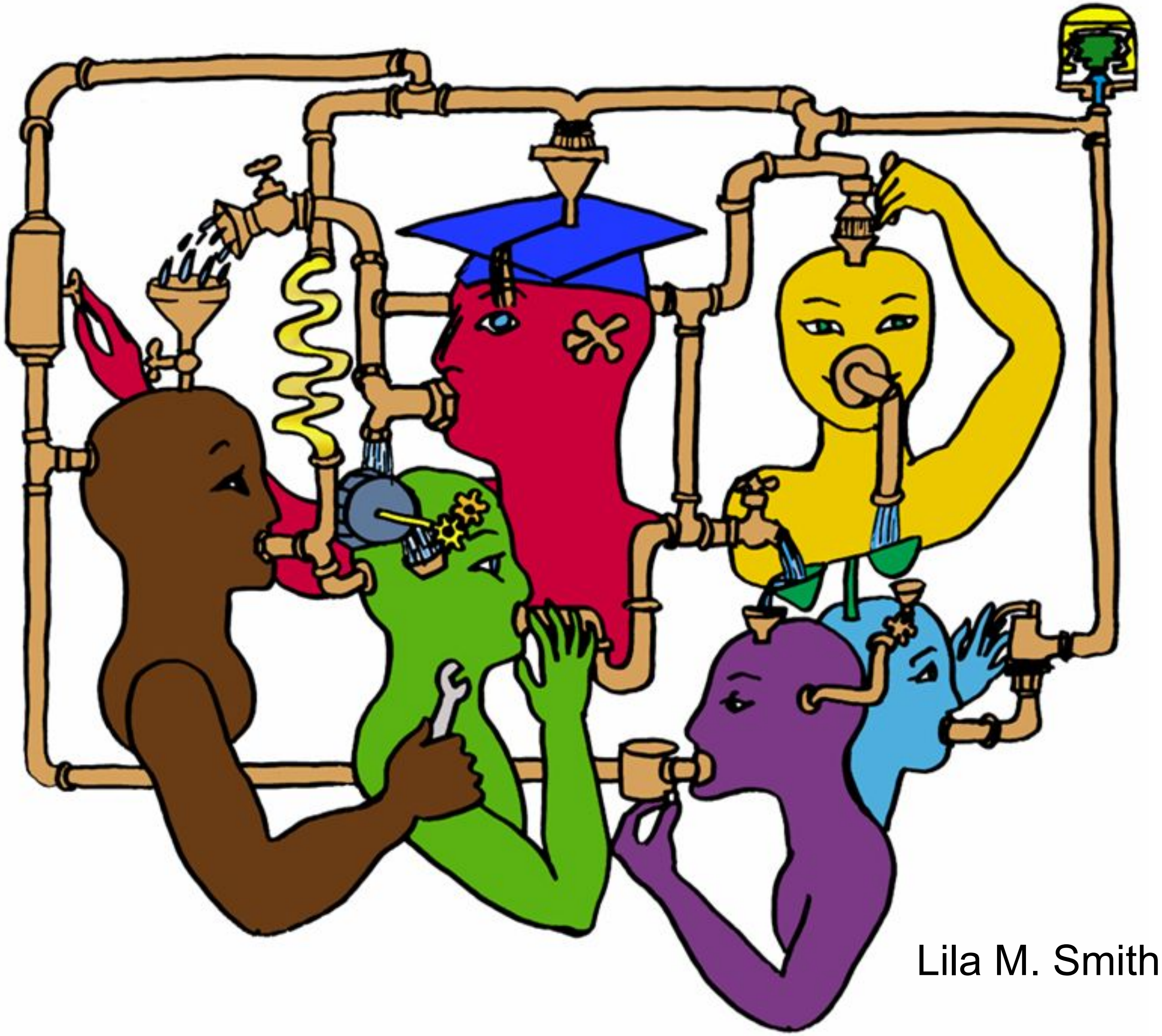
Karl’s Quandary

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

Theory – ?

Research – ?





Lila M. Smith

Cooperative Versus Collaborative Learning

Both Based on Social Interdependence Theory

	Cooperative Learning	**Collaborative Learning**
Structure	More structured, teacher-defined	Less structured, student-directed
Faculty Role	Organizer, supervisor	Facilitator, guide
Student Roles	Pre-assigned, behavior specific	Self-determined, flexible
Focus	Structured individual accountability and teamwork	Assumed shared responsibility and group cohesion
Goal	Task completion, skill mastery	Deep understanding, critical thinking
Use Case	Use **cooperative learning** when introducing new material, teaching foundational skills, or managing large groups with diverse abilities.	Use **collaborative learning** for advanced learners, open-ended projects, or tasks requiring creativity and critical thinking.

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.

[Smith, K.A., Sheppard, S.D., Johnson, D.W. and Johnson, R.T. 2005. Pedagogies of Engagement: Classroom-based Practices (cooperative learning and problem-based learning). Journal of Engineering Education, 94: 87–101]

Structuring Learning Goals To Meet the Goals of Engineering Education

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

The growing concern about engineering education in the United States has been the subject of many recent editorials and articles.* They point to the deteriorating quality of engineering and science education, the lack of adequate preparation in mathematics and science on the part of high school graduates, the shortage of engineers, and, especially, the shortage of college teachers of engineering. Unless corrective measures are taken, it may be more difficult in the coming years to achieve the goals of engineering education and to meet the needs of engineering students.

Goals of Engineering Education

The three major goals of engineering education are to promote technological, interpersonal, and social-technical competencies in engineering students. The achievement of *technological competence* requires the mastery and retention of science and engineering facts, principles, theories and analytical skills; the development of synthesis, design, modeling and problem solving skills; and the development of implementation skills for converting knowledge into action.

Interpersonal competence requires the development of the cognitive, affective and behavioral prerequisites for working with others to perform a task.[1] Among the skills required are communication, constructive conflict management, interpersonal problem solving, joint decision making and perspective-taking skills. Interpersonal competence is becoming increasingly important for engineers due to the tremendous technical complexity and the societal constraints of most problems. Engineers must now, more than ever, work with other engineers and scientists, economists, educators, consumer groups, and government regulatory agencies to reach satisfactory and mutually acceptable designs for future technology.

Social-technical competence requires gaining an understanding of the complex interdependencies between technology and society, of the influence of technology on individual and collective behavior and on the natural environment. Essentially, social-technical competence involves perspective-taking on a large scale that encompasses historical, social, psychological, and philosophical viewpoints, as well as an understanding of the basic premises underlying the interaction between society and technology.

Needs of Engineering Graduates

Many studies have been conducted on engineering education since it began at West Point in 1792, and these have been well summarized.[2] The earliest study (by Mann in 1918) called for a return to the basics; each of the subsequent ones emphasized diversity and a broad education,[3] and their general findings have been summarized by Cheit[4] in the following three statements:

1) There is renewed concern that, despite many efforts, engineering education is not yet incorporating what is called the "humanistic-social," "liberal," or "general" parts of the students' education.

2) Engineering education must be more broadly applied, that is, engineers must build bridges between science and the needs of society.

3) Engineers must be made decision makers, since, despite the growing importance of engineering to American life, engineers have not taken a correspondingly important part in the decision-making process.

The recommendations of these studies are similar and recurrent, but the need for change in engineering education remains. Currently, there appears to be a move away from the image of applied science in engineering education.[5] The basis of this apparent change is the growing realization that technological and economic feasibility are not the sole or even the main determinants of what engineers do. Ecological, social, cultural, psychological and political influences are equally important.

The results of the major studies of engineering education tie in closely with the need for developing social-technical competence and interpersonal competence in engineering graduates. Supporting this need, a major study at the University of California, Los Angeles, concluded that every engineering graduate must be capable of communicating with and working with people of other professions to solve the inter-

*See, for example, recent issues of *Engineering Education* (e.g., April 1981) and *Science* (e.g., "Trouble in Science & Engineering Education," by J. Walsh, vol. 200, no. 4470, 1980.)

ENGINEERING EDUCATION: December 1981 / 221

JEE December 1981

Cooperative Learning: An Evidence-Based Practice for Interactive Learning

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

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)

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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
- Give individual tests
- 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!

Key Elements:

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

Key elements of cooperative learning (CL) [CLHks.pdf]

Why Emphasize Cooperative Learning?

- **Student learning and retention**
- Essential for **transferable skill** development
- **Teamwork** is a high priority for **employers**

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.*

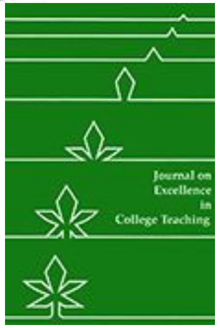
- Over 300 Experimental Studies
- First study conducted in 1924
- High Generalizability
- Multiple Outcomes

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



25 (3&4) 2014

Cooperative Learning - STEM - Meta Analysis

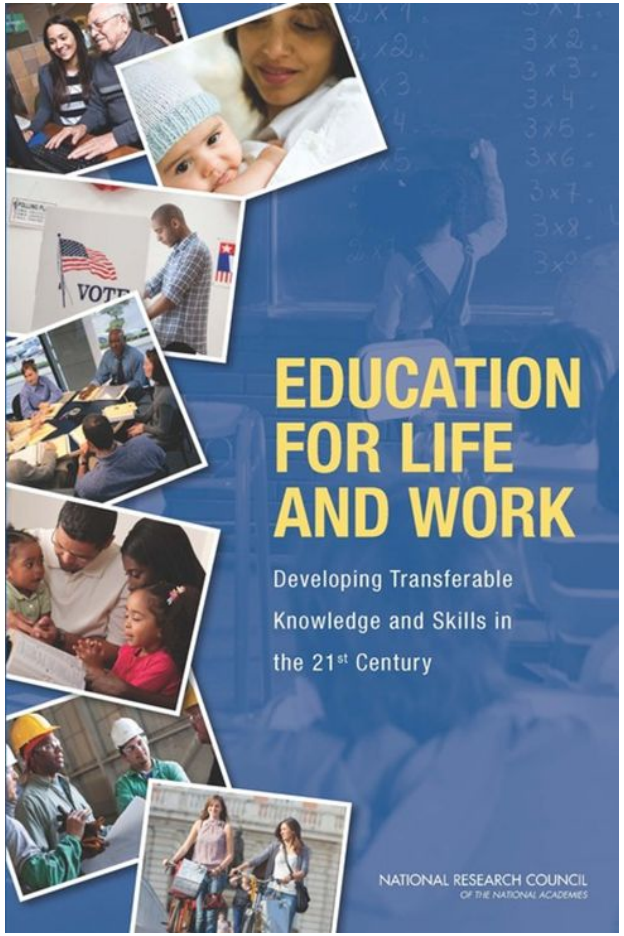
Springer, Stanne, and Donovan (1997, 1999) reported mean effect sizes for cooperative learnings effect on students' achievement and persistence of 0.51 and 0.46, respectively.

They observed that "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 STEM courses and programs by 22%."

Springer, L., Stanne, M. E., and Donovan, S. 1997. Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Madison, WI: National Institute for Science Education.*

Springer, L., Stanne, M.E., and Donovan, S. S. 1999. Effect of Small Group Learning on Undergraduates in Science, Mathematics, Engineering and Technology: A Meta-Analysis. *Review of Educational Research, 69*(1), 21–51.

Transferable Knowledge and Skills

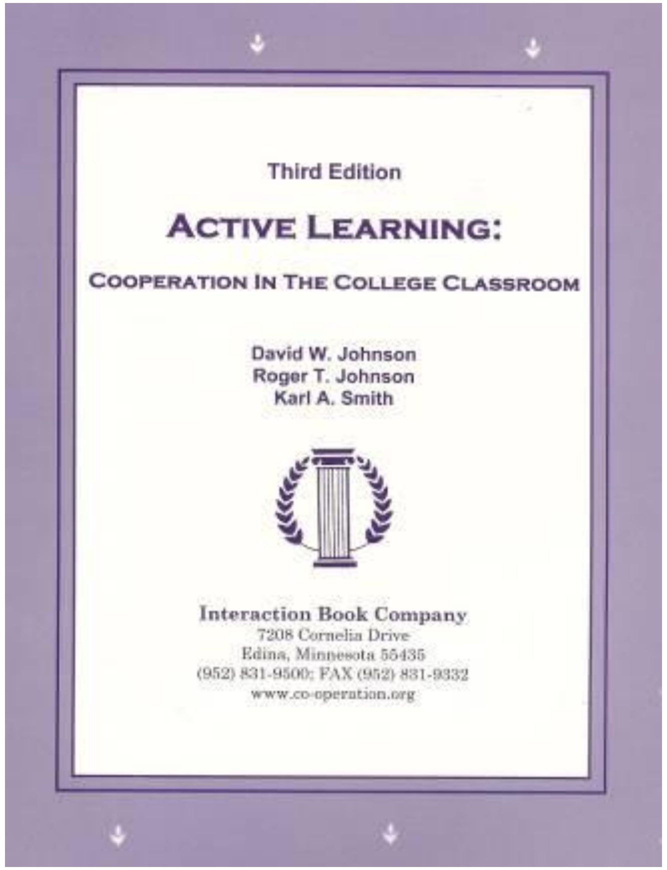


https://nap.nationalacademies.org/catalog/13398/education-for-life-and-work-developing-transferable-knowledge-and-skills

Cooperation in the College Classroom

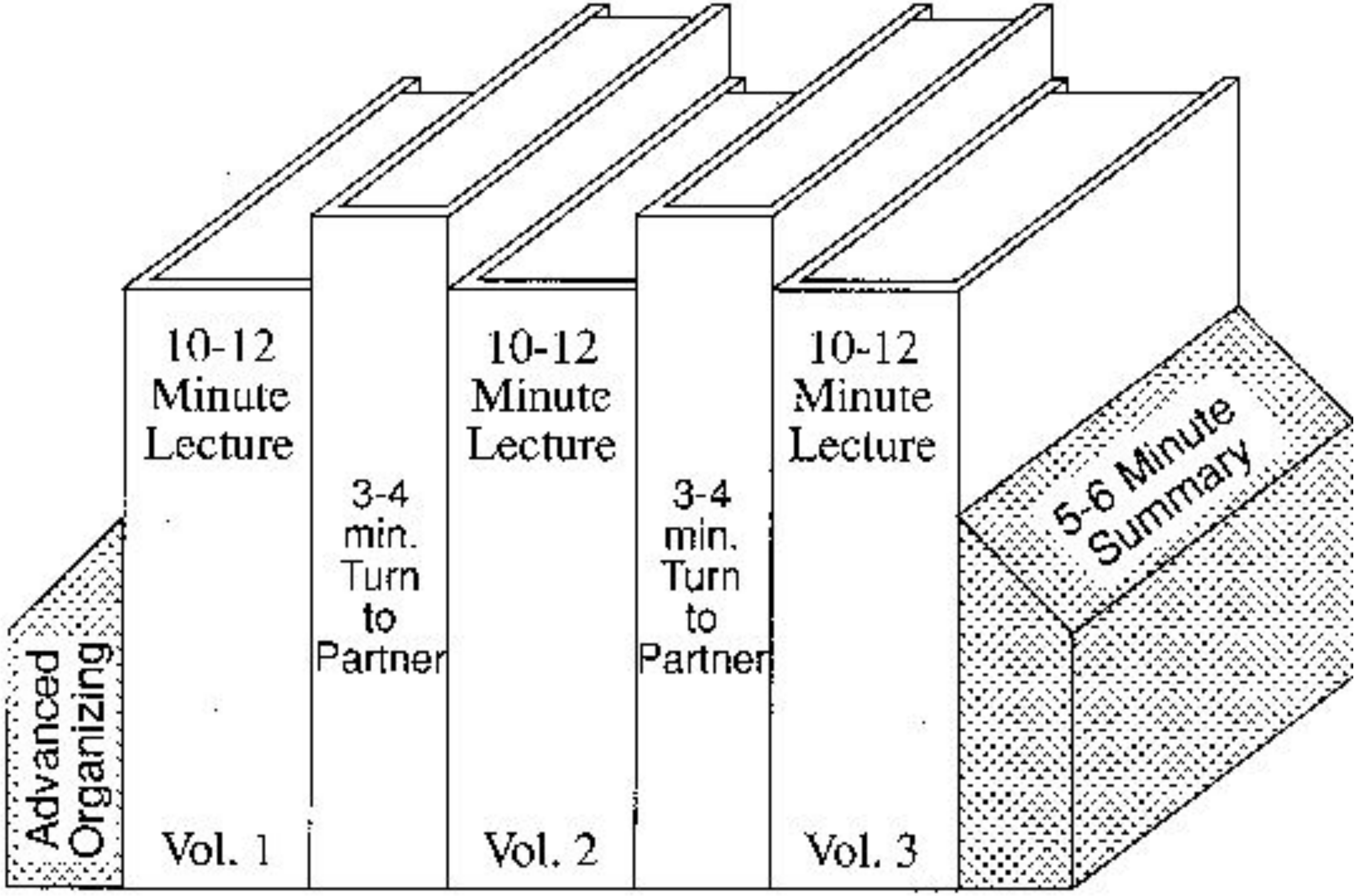
- **Informal** Cooperative Learning Groups
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups

Notes: <u>Cooperative Learning Notes</u>



First edition 1991.

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]

Book Ends on a Class Session

1. Advance Organizer

2. Formulate-Share-Listen-Create (Turn-to-partner) — *repeated every 10-12 minutes*

3. Session Summary (Minute Paper)
    1. What was the most useful or meaningful thing you learned during this session?
    2. What question(s) remain uppermost in your mind as we end this session?
    3. What was the “muddiest” point in this session?

1 Advance Organizer

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

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

❷ Formulate-Share-Listen-Create

Informal Cooperative Learning Group
Introductory Pair Discussion of a

FOCUS QUESTION

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

2 Focus Question Examples

- Give an example
- Describe an application…
- Explain in your own words…
- Paraphrase the idea
- Support the following statement…

Informal Cooperative Learning Planning Form

Description of the Class Session: ___________________________________

1. **Your Name, Department, and Course Title:** ______________________________
2. **Session Topic:** ____
3. **Objectives** (Major Understandings Students Need to Have At The End Of The Session):
   a. ____
   b. ____
4. **List the Enduring or Important to Know Outcome that this activity is targeting.**

   ____
5. **Time Needed:** ____
6. **Method for Assigning Students to Pairs Or Triads:** ________________________
7. **Method for Changing Partners Quickly:** ________________________________
8. **Materials** (such as slides or handouts 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 session will address.

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. ____

Celebrate Students' Hard Work

Provide a close to the activity by asking students to acknowledge their partner, for example by (1) thanking them or (2) mentioning one thing their partner did that helped them learn.

1. ____
2. ____

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 and one-time events (e.g., guest presentation)
- Include "book ends" procedure
- Are not as effective as Formal Cooperative Learning or Cooperative Base Groups

Cooperation in the College Classroom

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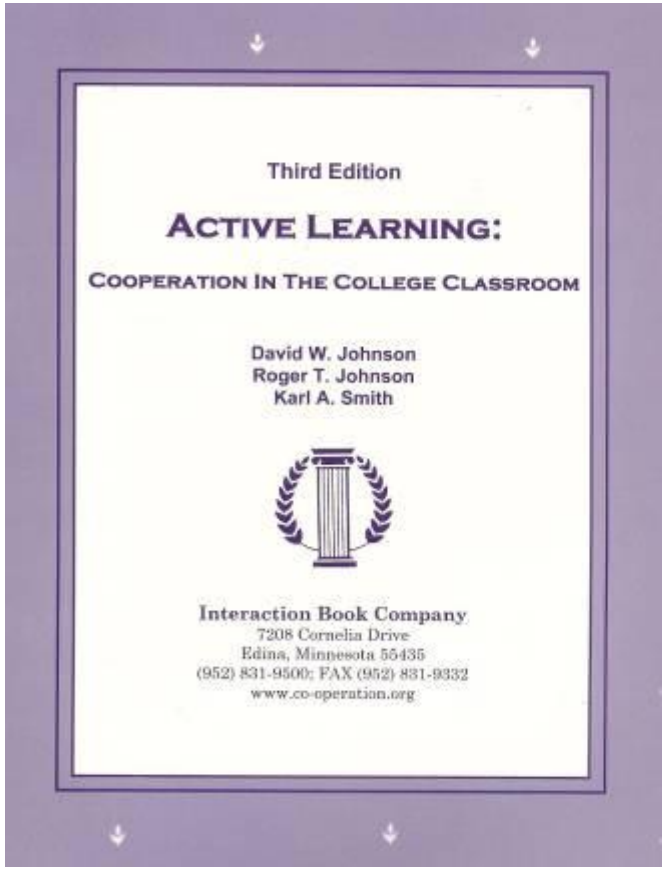
- **Formal** Cooperative Learning Groups
- Cooperative **Base** Groups

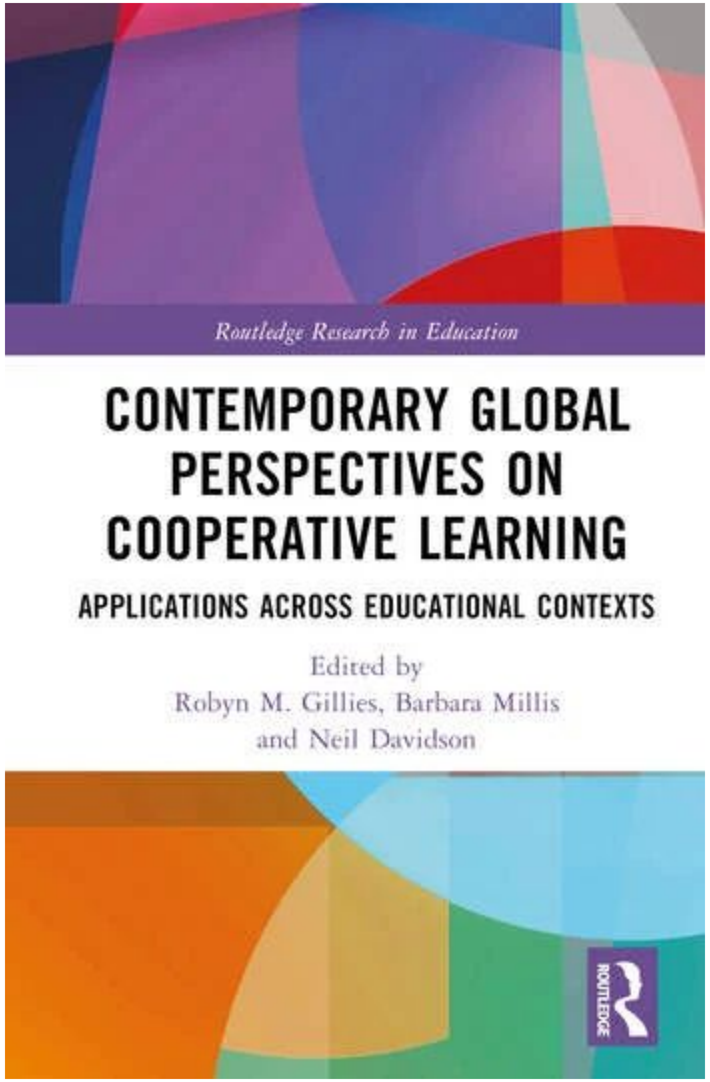
Notes: Cooperative Learning Notes



First edition 1991.

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



Smith, K.A. & Felder, R.M. 2023. Cooperative Learning in Engineering Education: The Story of an Ongoing Uphill Climb. In Robyn Gillies, Barbara Millis, and Neil Davidson, eds.

- Publisher Link
- ASU Library Link: Contemporary Global Perspectives on Cooperative Learning
    -
- Link to Draft

Cooperation in the College Classroom

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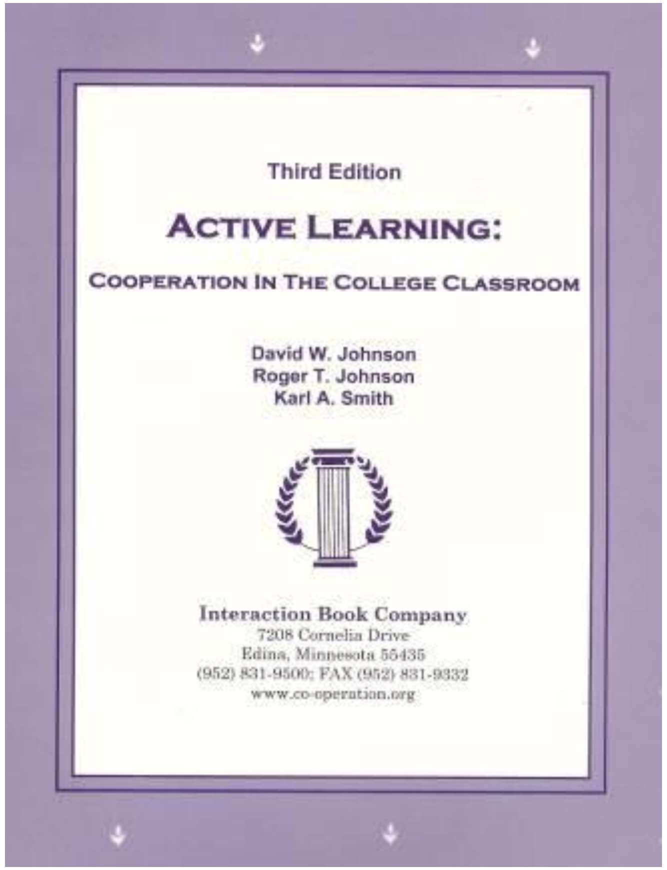
- Cooperative **Base** Groups

Notes: <u>Cooperative Learning Notes</u>



First edition 1991.

Cooperative Base Groups

Cooperative Base Groups are long-term, stable teams designed to support members' academic and personal development beyond class activities.

People illustrations by Storyset

Cooperative Base Groups

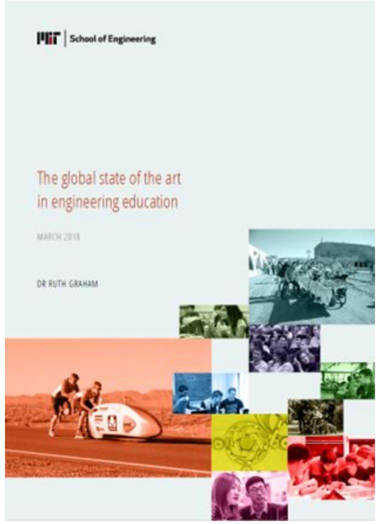
- **Meaningful Engagement**: Academic and interpersonal growth
- **Support & Accountability**
- **Self-Directed Management**: Groups self-organize meetings and activities.
- **Faculty provide guidance**

People illustrations by Storyset

Elements of a paradigm shift in engineering education

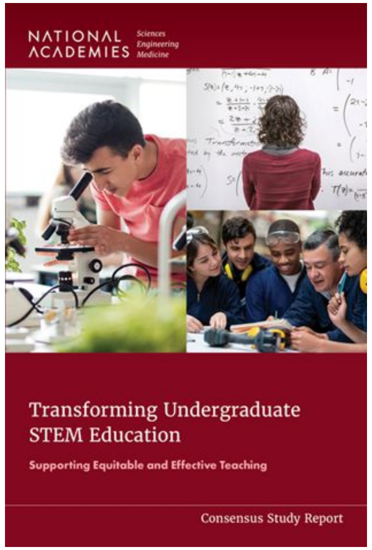
	Older paradigm	Newer paradigm
Knowledge	Transferred from faculty to students	Jointly constructed by students and faculty
Students	Passive vessels to be filled by faculty's knowledge	Active constructors, discoverers, and transformers of knowledge
Faculty purpose	Classify and sort students	Develop students' competencies and talents
Context	Competitive /individualistic	Cooperative
Climate	Conformity	Diversity
Assumption about teaching	Any expert can teach	Teaching is complex and requires considerable training

Johnson, Johnson & Smith (1991, 2006); Smith & Waller (1997); Smith & Felder (2023)



This is the future of the field, where you put the student at the center and use the resources to facilitate team projects and authentic experiences, and then put the taught curriculum online.

https://www.rhgraham.org/resources/Global-state-of-the-art-in-engineering-education---March-2018.pdf



Decades of research show that learning involves a set of complex processes and is shaped by the characteristics and experiences of learners, social interactions, and cultural context. **Studies are clear that student-centered instructional practices** that take students' interests and experiences into account and provide them with authentic opportunities to engage with disciplinary content, practices, and analysis **are more effective** than instructional practices that rely primarily on lecture, reading, and memorization of content, procedures, and algorithms.

https://nap.nationalacademies.org/catalog/28268/transforming-undergraduate-stem-education-supporting-equitable-and-effective-teaching

Session Summary (Minute Paper) Zoom Poll

1. What was the most interesting or valuable thing you learned?
2. What thing(s) helped you learn?
3. Rate the pace.
4. Rate the relevance.
5. Rate the instructional format.
6. Other comments or suggestions?

Questions & Discussion

Thank you!

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Additional Resources

- Learning and Teaching Hub Quick Reference Guides (QRGs)
  - Group Work - Cooperative Learning
  - Peer-led Study Groups
  - Classroom Response Systems and Polling
  - Minute Papers
  - Generation Z
- ASU Resources
  - ICAP Center for Teaching and Learning
- Literature
  - Smith, K. A., Sheppard, S. D., Johnson, D. W., & Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of engineering education*, *94*(1), 87-101.