Celebrating Active Learning:
Shared Missions and Practices in Models of Student Engagement

Design and Implementation of Cooperative Learning

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Learning: Emphasize Big Ideas (Enduring Outcomes)*

- ❑ How People Learn
- ❑ Streamlined Course Design
  - ❑ Alignment of Outcomes, Assessment and Instruction
- ❑ Interactive Learning

*See Streveler and Smith (2021), Course design in the time of coronavirus: Put on your designer's CAP. *Advances in Engineering Education*.

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

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Learning Requires…

Deliberate

- Cognitive load (bandwidth)
- Reflection
- Processing

Distributed

- Repetition over time
- Multiple input modes

Practice

- Attentive
- Constructive
- Interactive

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Learning Requires*

deliberate

distributed

practice

*Thanks to Ruth Streveler for these slides
Also see Brown, P.C., Henry L. Roediger III, H.L., & Mark A. McDaniel, M.A. (2014). *Make It Stick: The Science of Successful Learning.* Belknap Press: An Imprint of Harvard University Press

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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 over time
- 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.
**a concept widely attributed to Jerome Bruner, refers to a curriculum design in which key concepts are presented repeatedly throughout the curriculum, but with deepening layers of complexity, or in different applications.

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Key Implications

Practice what you want to learn

Attentive – 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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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)

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Session Layout

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

Implementing Cooperative Learning
- Practice
- Examples
- Applications

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Overall Goals

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

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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

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Reflection and Dialogue

Individually reflect on **your experience as an undergraduate student** with **Interactive (cooperative) learning**. Write for about 1 minute.
- 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?

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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Pour it in model

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Karl's Quandary

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

Theory – ?

Research – ?

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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
- History and Philosophy of Education
- Small Group Procedures for Personal and Organizational Change
- Social psychology of learning – student – student interaction

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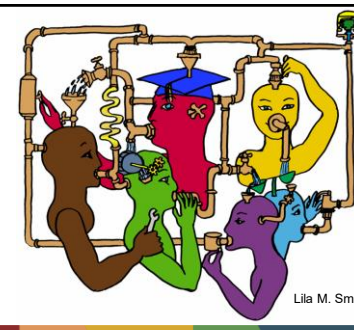
Keep it flowing around model



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Cooperative Learning

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

Research – Randomized Design Field Experiments

Practice – Formal Teams/Professor's Role

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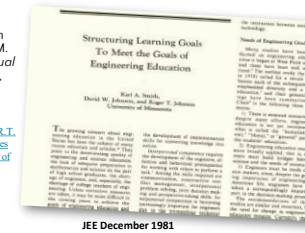
Cooperative Learning Introduced to Engineering – 1981

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

JEE December 1981

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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).

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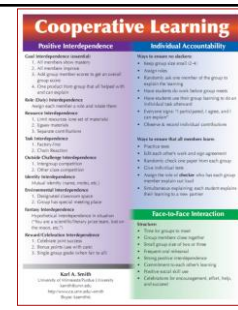

Key Elements:

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

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

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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.*

Benefits

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

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

Johnson, Johnson, & Smith (2007, 2014)

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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.

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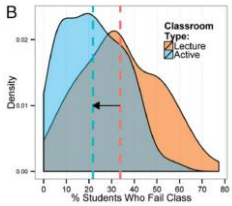
Interactive Learning = Reduced Failure Rate



See: Freeman, et.al. (2014)

Engineering Thermodynamics
PLSG earned statistically almost **one full letter grade higher** than students in the no-treatment group; they were also statistically **more likely to have passed the course** and to have graduated with their degree approximately one year after taking it

Milcarek, R., et.al. (2025) The Impact of Peer-led Study Groups on Student Achievement in a Gateway Engineering Thermodynamics Course. https://advances.asee.org/wp-content/uploads/vol13/Issue1/13.1_4_Brunhaver.pdf

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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

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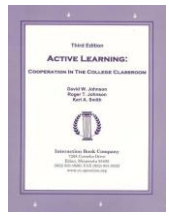
Cooperation in the College Classroom

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

Notes: Cooperative Learning Notes



First edition 1991.

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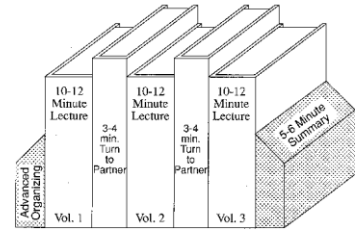
Book Ends on a Class Session



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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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?

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1 Advance Organizer

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

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

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2 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

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2 Focus Question Examples

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

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

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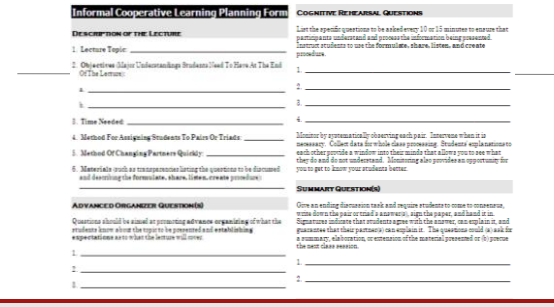

Informal Cooperative Learning Planning Form

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) pose the next class session.

1. _____
2. _____

https://karlsmithmn.org/wp-content/uploads/2017/08/Informal%20Cooperative%20Learning%20Planning%20Form.doc

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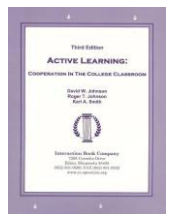
Notes: Cooperative Learning Notes



First edition 1991.

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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

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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.

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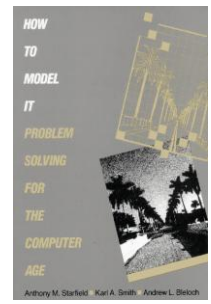

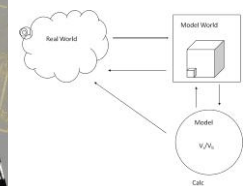

*Based on First Year Engineering course – Problem-based cooperative learning *How to Model It* published in 1990.

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Group Processing Plus/Delta Format

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

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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

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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

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Decisions, Decisions…

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

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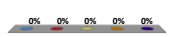
Optimal Group Size?

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



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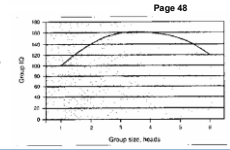
Formal Cooperative Learning Task Groups

Page 48

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

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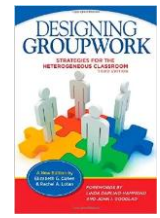
Assigning Roles



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

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Teamwork Skills

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

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

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TEAMWORK

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

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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

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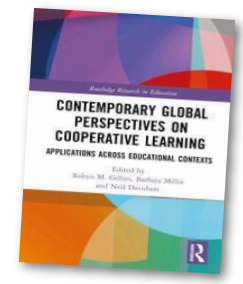
Smith, K.A. & Felder, R.M. 2023. Cooperative Learning in Engineering Education: The Story of an Ongoing Uphill Climb. In Robyn Gillies, Barbara Millis, and Neil Davidson, eds. Contemporary Global Perspectives on Cooperative Learning Link to Draft



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Notes: Cooperative Learning Notes

First edition 1991.

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Student Support is Essential

Academic Support	Personal Support
Classmates and faculty: Help students succeed academically.	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.

See: Johnson, Johnson and Smith (2006)

https://advances.asee.org/aee-covid-19-home-page/

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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

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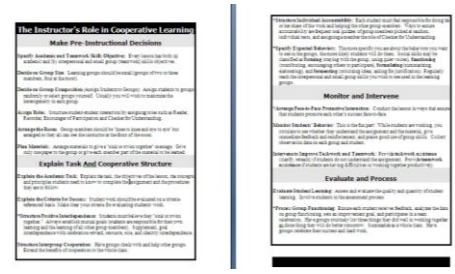

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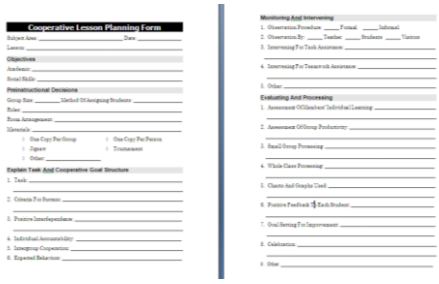

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Reflection and Dialogue

Individually reflect on the cooperative learning workshop:

- **Most interesting, valuable, useful thing you learned.**
- **Things that helped you learn.**
- **Questions, comments, suggestion**

Think/write individually for about 1 minute.

Discuss with your neighbor for about 2 minutes

Select/create a response – question or comment – to present to the whole group if you are randomly selected

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Questions & Discussion

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Thank you!

An eCopy of this presentation will be posted to karlsmithmn.org

/karl-smith-5581401 ksmith@umn.edu karlsmithmn.org

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