Session Layout

**BIG IDEAS (Enduring Outcomes)**
- How Learning Works
- Streamlined Course Design
- Alignment of Outcomes, Assessment and Instruction
- Interactive Learning

**Neuroscience of Learning (How people learn)**
- Key Elements
- Implications
- Processes that Support Learning
- Conditions/Limitations for Learning

**Streamlined Course Design**
- Alignment of Outcomes, Assessment and Instruction
- Course Concept Map

**Assessment Overview**
- Types of assessment
- Writing learning objectives
- Mapping objectives on a taxonomy exercise

**Interactive (Cooperative) Learning**
- Description & Rationale
- Cooperative Learning
  - Key Concepts
  - Types of Cooperative Learning
- Informal Cooperative Learning planning exercise
Pre-workshop Survey

[Bar chart showing survey results]

MOT 8221 – Spring 2019 Background Survey

<table>
<thead>
<tr>
<th>Subject</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
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<td>1.8</td>
<td>2.2</td>
<td>1.7</td>
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</table>

N = 19/21
It is strange that we expect students to learn, yet seldom teach them anything about learning. We expect students to solve problems, yet seldom teaching them anything about problem solving. And, similarly, we sometimes require students to remember a considerable body of material, yet seldom teach them the art of memory. It is time we made up for this lack...


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**Big Ideas (Enduring Outcomes)**

- Neuroscience of Learning (How People Learn)
- Streamlined Course Design
- Alignment of Outcomes, Assessment and Instruction
- Interactive Learning
The Neuroscience of Learning

- Key Concepts: This is your Brain...
- Processes that Support Learning
- Conditions/Limitations for Learning
- Implications

This is your brain...

- Brain cells are called **neurons**.
- You are born with at least **100 billion neurons**.
- **Dendrites** (fibers) grow out of the neurons when you listen to/write about/talk about/practice something, that is, when you are learning something.
This is your brain. . .

- Neurons know how to grow dendrites, just like a stomach knows how to digest food.
- **Learning = Growth of dendrites.**
- New dendrites take time to grow because it takes a lot of practice for them to grow.

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Memory

Types of Memory:
- Working, short-term memory
- Long-term memory: Explicit and Implicit
  - Declarative
  - Procedural
  - Episodic
  - Semantic
Processes that Support Learning

- Processes
  - Metacognition
  - Executive Functioning
  - Self-Regulation

- Key Questions on Processes
  - How do we define the processes?
  - How do we use the processes to orchestrate learning?

Conditions for Learning

- Motivation
  - Influences and Barriers

- Conditions for Learning
  - Physical
  - Cognitive
  - Emotional
  - Collaboration
Limitations

- Cognitive Load
- Learning Barriers
  - Content
  - Incentive
  - Social
- Stress

Implications

- Culture and Context of Learning in the Classroom
  - Environment
  - Asset v. Deficit Model
- Instructional Approaches
  - Individual learning differences
  - Problem-based; Project-based
  - Interactive (Collaborative)
  - Assessment
1. Students prior knowledge can help or hinder learning
2. How students organize knowledge influences how they learn and apply what they know
3. Students’ motivation determines, directs, and sustains what they do to learn
4. To develop mastery, students must acquire component skills, practice integrating them, and know when to apply what they have learned
5. Goal-directed practice coupled with targeted feedback enhances the quality of students’ learning
6. Students’ current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning
7. To become self-directed learners, students must learn to monitor and adjust their approach to learning

Streamlined Course Design

Streamlined Course Design is a guided process that is based on the engineering design process.

The end product is a course where what is learned, how that learning is measured, and the learning environment are all aligned.
Common Instructional Design Approach

Choose Text

Identify Chapters Covered

Develop Lectures

Create Exams

Why Streamline?

• Aligned courses — students are learning what “matters” and you have evidence about their learning

• Increased student learning — about the things that matter

• Increased satisfaction by instructors and students about their experience in the course
**The Engineering Design Process vs. Streamlined Course Design Process**

**Engineering Design**
- Determine requirements/specifications
- Develop or use established metrics to measure against outcomes
- Plan and develop process, system, etc. to implement

**Streamlined Course Design Process**
- Identify the desired results
- Determine acceptable evidence
- Plan learning experiences

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**Curricular Priorities: What are they?**

First – how do you want your students to be different when they leave the class? What should they know, be able to do, care about?

Second – how can you rank what you listed in #1 as most important?

Wiggins and McTighe called these “curricular priorities”
- Enduring outcomes – enduring long after the course is over
- Important to know – Knowledge, Skills, and Attitudes (KSA) needed to arrive at the enduring outcomes
- Good to be familiar with – good if they can recognize, but nothing vital

Note these are not necessarily written as LEARNING OBJECTIVES (that is a separate step).
Curricular Priorities

Categorize outcomes into three levels

- Good to be familiar with
- Important to know
- Enduring outcomes

From Wiggins and McTighe

How to Determine Curricular Priorities

Big ideas:
- What lies at the heart of the discipline?
- What do professionals/experts do?

Essential questions:
- What questions do you want your students to ask as they learn the material?

What are the guiding concepts and how do those concepts relate to one another?
- A graphic like a concept map is one way to discover relationships
Curricular Priorities Worksheet

1. List curricular priorities of the course you plan to (re)design (~ 2 min)
   1. Enduring outcomes
   2. Important to know outcomes
   3. Good to be familiar with outcomes

2. Share and discuss curricular priorities with a neighbor (~5 min)

Curricular Priorities Worksheet – Part 2

1. As a follow up, please consider creating a concept map of the course that includes enduring outcomes, important to know, and good to be familiar with items.
**What are concept maps and why use them?**

What are concept maps?
- Concept maps are graphical tools for organizing and representing knowledge ([http://cmap.ihmc.us](http://cmap.ihmc.us)).

Why use concept maps?
- They are a tool for helping you think about how the concepts in your target domain are connected.
- **They help you discover what is most important** – thus are useful for determining curricular priorities and for identifying difficult or threshold concepts.

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**Concept Maps Software Tools**

*FREE*

Cmap Tools ([http://cmap.ihmc.us](http://cmap.ihmc.us))
- Institute for Human & Machine Cognition
- Free downloadable program
- Site also has links to instructional videos on how to use Cmap

*Commercial* software with free trials

Inspiration
Learning Objectives = the bridge between content and assessment

WHY?
- Learning objectives are the mechanism for making the learning MEASURABLE. So you CAN assess it!

What? Learning objectives are statements that are:
- **S**pecific
- **M**easurable (Describable)
- **A**ttainable
- **R**elevant
- **T**ime-bound

Why assess?

Designer’s perspective:
- Assessment is the measure YOU need to know if your design is working as you would like it to.
- Analogous to the measuring against the specs of a technical design.
- Writing learning objective is like writing the specs.
Why assess?

Learners’ perspective
◦ How will LEARNERS know they learned the material?
◦ How will LEARNERS reflect on what they have practiced?
◦ How will LEARNERS be able to practice what they need to learn?

Assessment as:
◦ A form of learning
◦ A form of reflection
◦ A form of deliberate, distributed practice

Types of Assessment

1. Diagnostic Assessment
   Conducted at the beginning of an instructional unit, course, semester. . . to determine the present level of knowledge, skill, interest. . . of a student, group or class.

2. Formative Assessment
   Conducted periodically throughout the instructional unit. . . to monitor progress and provide feedback toward learning goals.

3. Summative Assessment
   Conducted at the end of an instructional unit or semester to judge the quality and quantity of student achievement and/or the success of the instructional unit.
Writing Learning Objectives

1. WHEN DO YOU WRITE LEARNING OBJECTIVES?
2. HOW DO YOU WRITE LEARNING OBJECTIVES?
3. EXAMPLES
When Do You Write Learning Objectives

Learning Objectives

- Optional
- Important
- Must be present!

Curricular Priorities

Constructing Learning Objectives
Using Verb-Noun Format

Alignment of CONTENT and ASSESSMENT
The VERB should be appropriate for the desired levels of Knowledge and Cognitive Processes
Acceptable evidence of learning
Concrete, Observable, Measurable

Verb
Taxonomies of Learning Objectives

What is a taxonomy?
How do you use them?
Why are they useful?
When do you use them?

Bloom’s taxonomy of educational objectives: Cognitive Domain (Bloom & Krathwohl, 1956)

A taxonomy for learning, teaching, and assessing: A revision of Bloom’s taxonomy of educational objectives (Anderson & Krathwohl, 2001).

Taxonomy of significant learning (Fink, 2003)

Evaluating the quality of learning: The SOLO taxonomy (Biggs & Collis, 1982)

Facets of understanding (Wiggins & McTighe, 1998)
Anderson and Krathwohl taxonomy

AN UPDATED VERSION OF BLOOM’S TAXONOMY

Revised Bloom’s Taxonomy

The Cognitive Process Dimension represents a continuum of increasing cognitive complexity—from lower order thinking skills to higher order thinking skills. Anderson and Krathwohl (2001) identify nineteen specific cognitive processes that further clarify the scope of the six categories (Table 2).

<table>
<thead>
<tr>
<th>lower order thinking skills</th>
<th>higher order thinking skills</th>
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<tbody>
<tr>
<td><strong>remember</strong></td>
<td><strong>apply</strong></td>
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<tr>
<td>recalling</td>
<td>executing</td>
</tr>
<tr>
<td>interpreting</td>
<td>applying</td>
</tr>
<tr>
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<td>checking</td>
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<tr>
<td>recalling</td>
<td>redesigning</td>
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<tr>
<td>summarizing</td>
<td>constructing</td>
</tr>
</tbody>
</table>

(Table 2 adapted from Anderson and Krathwohl, 2001, pp. 67–68)

Examples of Objectives that Map to Bloom

1. List the six levels of the revised Bloom’s taxonomy
2. Explain in your own words the first three levels
3. Map the following learning objectives to a level on Bloom’s taxonomy:
   - At the end of the course, students will be able to
     - Solve mass transfer problems using Fick’s law
     -Enumerate the essential components in a control loop
     -Build a functional prototype of a membrane separation system for a set of given operating conditions

Adapted from Michael Prince’s Workshop “How to engineer engineering education”, July 2016

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Examples of Objectives that Map to Bloom

4. An instructor wrote the following learning objective for an enduring outcome:
   - Classify different forms of assessment into authentic or non authentic
   - Does it sound appropriate? Could you improve it?
5. Choose the appropriate level on Bloom’s taxonomy for the outcomes of your course justifying, your choice
6. Write the learning objectives of your course at different levels of Bloom’s taxonomy

Adapted from Michael Prince’s Workshop “How to engineer engineering education”, July 2016
Activity Part I (~3 Minutes):
Write your Learning Objectives (LO)s

On your own, write LOs for your *enduring outcomes* first. If time allows, try to write one LO for an *important to know* piece of your curricular priorities.

Activity Part II (~5 Minutes)
Discuss with your Neighbor

Share your learning objectives (LOs) with your breakout group. Do your LOs seem *SMART* and well-written to your peers?
Revised Bloom’s Learning Taxonomy

The Knowledge Dimension classifies four types of knowledge that learners may be expected to acquire or construct—ranging from concrete to abstract (Table 1).

<table>
<thead>
<tr>
<th>concrete knowledge</th>
<th>abstract knowledge</th>
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<tbody>
<tr>
<td>factual</td>
<td>metacognitive*</td>
</tr>
<tr>
<td>knowledge of terminology</td>
<td>knowledge of cognitive tasks, including appropriate contextual and conditional knowledge</td>
</tr>
<tr>
<td>knowledge of specific details and elements</td>
<td>self-knowledge</td>
</tr>
<tr>
<td>knowledge of classifications and categories</td>
<td>knowledge of subject-specific skills and algorithms</td>
</tr>
<tr>
<td>knowledge of generalizations</td>
<td>knowledge of subject-specific techniques and methods</td>
</tr>
<tr>
<td>knowledge of principles and generalizations</td>
<td>knowledge of criteria for determining when to use appropriate procedures</td>
</tr>
<tr>
<td>knowledge of theories, models, and structures</td>
<td>strategic knowledge</td>
</tr>
</tbody>
</table>

(Table 1 adapted from Anderson and Krathwohl, 2001, p. 46.)

*Metacognitive knowledge is a special case. In this model, metacognitive knowledge is knowledge of [one’s own] cognition and about oneself in relation to various subject matters ... (Anderson and Krathwohl, 2001, p. 44).”


Revised Bloom’s Learning Taxonomy

A statement of a learning objective contains a verb (in action) and an object (usually a noun).

- The verb generally refers to actions associated with the intended cognitive process.
- The object generally describes the knowledge or skill students are expected to acquire or construct. (Anderson and Krathwohl, 2001, pp. 4-5)

In this model, each of the colored blocks above an example of a learning objective that generally corresponds with each of the various combinations of the cognitive process and knowledge dimensions.

Remember: these are learning objectives—not learning outcomes. It may be useful to think of providing each objective with something like “Students will be able to...”


Mapping Learning Objectives

Example from Ruth Wertz

<table>
<thead>
<tr>
<th>Knowledge Dimension</th>
<th>Map of Week 5 Learning Objectives</th>
<th>Cognitive Process Dimension</th>
</tr>
</thead>
</table>
| A. Factual Knowledge      | 1. Remember                       | 1. Remember
|                           |                                   | L2-GA                       |
| B. Conceptual Knowledge   |                                   | 2. Understand               |
|                           |                                   | L1-IK                       |
| C. Procedural Knowledge   |                                   | 3. Apply                    |
|                           |                                   | L3-IK                       |
| D. Metacognitive Knowledge|                                   | 4. Analyze                  |
|                           |                                   | L4-EU                       |
|                           |                                   | L3-EU                       |

(Framework: Anderson & Krathwohl, 2001)

Content:
- [L1] Describe the meaning of the relationship between stress and strain.
- [L2] Define the modulus of elasticity, shear modulus, and Poisson’s ratio
- [L3] Describe the physical meaning of effective stress
- [L4] Compute total and effective vertical stresses under hydrostatic and seepage conditions
- [L5] Estimate induced stresses at a discrete point or along a plane, due to an applied load

Fink

TAXONOMY OF SIGNIFICANT LEARNING OUTCOMES
1. Foundational Knowledge
   • "Understand and remember" learning
     For example: facts, terms, formulae, concepts, principles, etc.

2. Application
   • Thinking: critical, creative, practical (problem-solving, decision-making)
   • Other skills
     For example: communication, technology, foreign language
   • Managing complex projects

3. Integration
   • Making "connections" (i.e., finding similarities or interactions) . . .
     Among: ideas, subjects, people

4. Human Dimensions
   • Learning about and changing one's SELF
   • Understanding and interacting with OTHERS

5. Caring
   • Identifying/changing one's feelings, interests, values

6. Learning How to Learn
   • Becoming a better student
   • Learning how to ask and answer questions
   • Becoming a self-directed learner

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Application of Fink Taxonomy

Joi Mondisa - Developing Self-identity, Confidence, and Community: The NLFN STEM Girls’ Mentoring Program Curricular Project

<table>
<thead>
<tr>
<th>Taxonomy Level</th>
<th>Learning Objective</th>
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<tr>
<td>Foundational Knowledge</td>
<td>Recall at least three specific STEM career opportunities ....(LO6)</td>
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<tr>
<td>Integration</td>
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<tr>
<td>Human Dimension</td>
<td>Describe two personal strengths (LO3)</td>
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<tr>
<td>Caring</td>
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<tr>
<td>Learning how to Learn</td>
<td>Feel comfortable working together with others and constructing meaning with others (LO5)</td>
</tr>
<tr>
<td>Application</td>
<td>Create and engage in making a Legos robot in a robotic competition. (LO7)</td>
</tr>
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</table>
Learning Objectives and Taxonomies

Further Resources


- Two websites about (1) changes to Bloom’s Taxonomy and (2) the revised Bloom’s Taxonomy

- Fink’s Taxonomy – Self Directed Guide

Aligning instruction with curricular priorities
Essential Questions

Are there useful ways to categorize different kinds of “active” or more student-centered teaching strategies?

How does one decide which kind of activity to use?

Framework for looking at “active” learning

<table>
<thead>
<tr>
<th>ACTIVE—ATTENTIONAL</th>
<th>CONSTRUCTIVE</th>
<th>INTERACTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doing something <strong>physically</strong> Paying Attention</td>
<td>Producing outputs that go beyond presented information</td>
<td>Dialoguing substantively on the same topic, and not ignoring a partner’s contribution</td>
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<tr>
<td>Engaging activities</td>
<td>Self-construction</td>
<td>Guided-construction</td>
</tr>
<tr>
<td>Attending processes</td>
<td>Creation processes</td>
<td>Joint creation processes</td>
</tr>
</tbody>
</table>

ICAP framework, Michelene T.H. Chi
“Attentional” strategies

Attention is the gateway to learning

However, many of us live in a state of continuous partial attention

Strategies to help your student pay attention are important.

Examples:
- Assigning observation roles while watching a live demonstration or video
- Asking students to repeat what another student has said
- Providing handouts with “fill in the blank” sections

Constructive activities

Research on learning has shown that we learn new information by connecting new information to what we already know (this is called “Constructivism”)

Constructive activities help your students make that bridge between new and previous knowledge

Examples:
- Providing an example of a concept or theory
- Explaining something in one’s own words
- Converting written or numerical information into a diagram or graph
From Constructive Learning to Interactive Learning

Gaining students’ attention and engaging them in constructive learning activities is more effective than when students are passive; however, it’s not the best we know how to do.

Interactive learning is most effective and can bring about the highest learning gains.

However, interactive learning is also the most time-intensive (for instructors and learners). Use it when you need it most (with the most important and difficult concepts).

So... look at your curricular priorities. Those that are the most important (enduring outcomes and important to know) are worth the “investment” in constructive and interactive activities.

Question: Your Experiences with Interactive Learning

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?
Karl’s Experience

First Teaching Experience – Third-year course in metallurgical reactions – thermodynamics and kinetics
Karl’s Quandary

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

 Theory – ?

Research – ?
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

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

Cooperative Learning Introduced to Engineering – 1981

Undergraduate Teaching Faculty: The 2013–2014 HERI Faculty Survey

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

Undergraduate Teaching Faculty, 2011*

<table>
<thead>
<tr>
<th>Methods Used in “All” or “Most”</th>
<th>STEM women</th>
<th>STEM men</th>
<th>All other women</th>
<th>All other men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperative learning</td>
<td>60%</td>
<td>41%</td>
<td>72%</td>
<td>53%</td>
</tr>
<tr>
<td>Group projects</td>
<td>36%</td>
<td>27%</td>
<td>38%</td>
<td>29%</td>
</tr>
<tr>
<td>Grading on a curve</td>
<td>17%</td>
<td>31%</td>
<td>10%</td>
<td>16%</td>
</tr>
<tr>
<td>Student inquiry</td>
<td>43%</td>
<td>33%</td>
<td>54%</td>
<td>47%</td>
</tr>
<tr>
<td>Extensive lecturing</td>
<td>50%</td>
<td>70%</td>
<td>29%</td>
<td>44%</td>
</tr>
</tbody>
</table>

Why Emphasize Cooperative Learning?

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

Cooperative Learning Research Support

- 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

*CLReturnstoCollege.pdf*
Engaged Pedagogies = Reduced Failure Rates

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

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

Observational study of over 2000 classes – most common behaviors:
• Faculty
  o Lecturing
  o Writing in real time
  o Posing nonrhetorical questions
  o Following-up on questions
  o Answering student questions
  o Clicker questions
• Students
  o Listening to instructor
  o Answering instructor questions
  o Asking questions

http://science.sciencemag.org/content/sci/359/6383/1468.full.pdf

8/16/2019
Pedagogies of Engagement

Cooperation in the College Classroom

Informal Cooperative Learning Groups

Formal Cooperative Learning Groups

Cooperative Base Groups

Notes: Cooperative Learning Handout [Smith-CL-College-Notes-817.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.

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
2 Focus Question Examples

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

Activity: Developing a “Book Ends on a Class Session” Plan

**Total Activity Time: ~15 minutes**

Part 1: Individual Exercise (~5 minutes)

Part 2: Small Group Discussion (~10 minutes)

Part 3: Lightning Talk Report Out (if time)
Informal Cooperative Learning Planning Form

Activity Part I (5 Minutes)

Sketch Plan

1. List Session Topic*
2. Learning Objective (for an Enduring Outcome)*
3. List Activity*
4. Write 2 – 3 “focus” questions.

*Use the same information here as you did for the earlier activities.
Activity Part II (5 Minutes)
Discuss with your Neighbor

Share your plan and focus questions with your neighbor.

Activity Part III - Lightning Talk Report Out

Share the key takeaways from your small group discussion on your plans. Were there any similarities with plans or questions?
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

Session Summary (Minute Paper)

Reflect on the session

1. Most interesting, valuable, useful thing you learned.
2. Things that helped you learn.
3. Question, 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
Q4 – Pace: Too slow 1 . . . 5 Too fast (3.5)
Q5 – Relevance: Little 1 . . . 5 Lots (4.4)
Q6 – Format: Ugh 1 . . . 5 Ah (4.3)