Parimal and Pramod Chaudhari Centre for Learning and Teaching

Indian Institute of Technology Bombay

Applying Research-based Instructional Strategies

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Workshop Overview

- **Part 1:** Writing Effective Course Learning Outcomes
  - Morning, Wednesday, 8 January 2020

- **Part 2:** Applying Research-based Instructional Strategies
  - Afternoon, Wednesday, 8 January 2020

- **Part 3:** Developing Course Assessment Plans
  - Morning, Thursday, 9 January 2020

- **Part 4:** Facilitating Student Use of Metacognitive Learning Strategies
  - Afternoon, Thursday, 9 January 2020

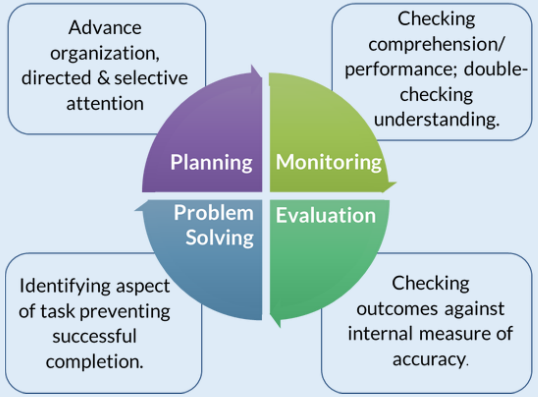
Workshop Overview

Writing Effective Learning Outcomes

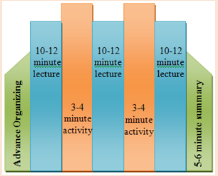
Designing Course Assessment Plans Aligned with Learning Outcomes

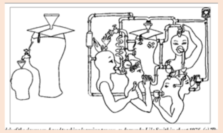
	Where the learner is going	Where the learner is	How to get there
Teacher	Clarifying, sharing and understanding learning intentions	Engineering effective discussions, tasks, and activities that elicit evidence of learning	Providing feedback that moves learners forward
Peer		Activating students as learning resources for one another	
Learner		Activating students as owners of their own learning	

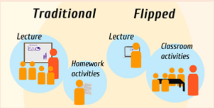
Facilitating Student Use of Metacognitive Learning Strategies

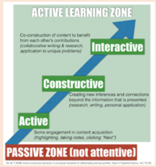


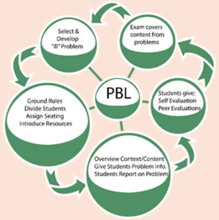
Designing Research-based Instructional Strategies Aligned with Learning Outcomes

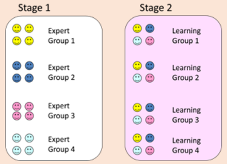










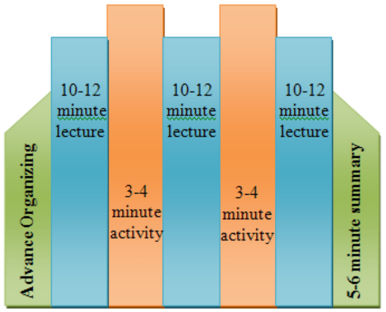


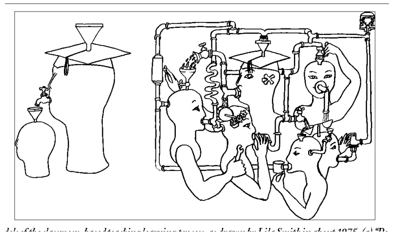
Workshop Ground Rules

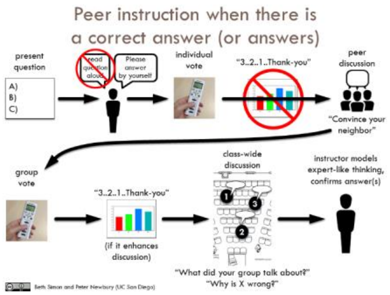
- **Ownership:** It is your workshop
- **Questions:** Ask when you have a question.
- **Slides:** The most recent copy of the slides will be available after the workshop
- Purposes of the Slides
  - Guide Workshop
  - Second Visual Source of Information
  - Resource after Workshop

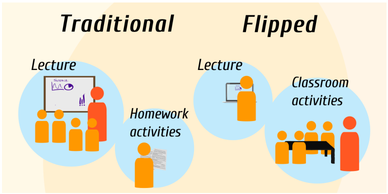
Overview

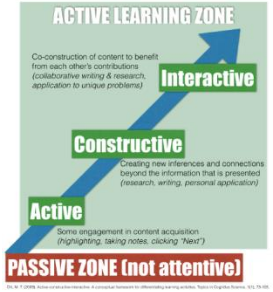
- Bookend Lecture Template
- Peer Instruction
- Differentiated Overt Learning Activities Framework
- Worked Examples
- Jigsaw
- Elements of Cooperative Learning
- Flipped / Inverted / Blended / Hybrid Learning
- Problem-based / Project-based / Challenge-based Learning
- Teams

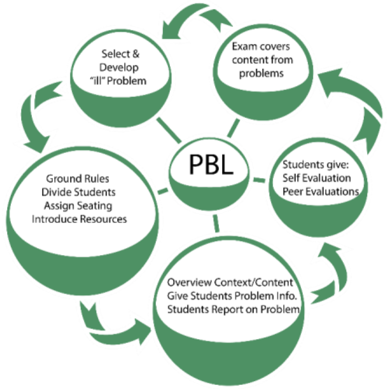


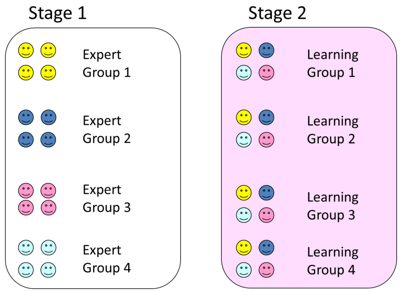












Efficacy of Research-based Instructional Strategies

F’03 - Traditional Lecture

S’04 - Interactive Instruction

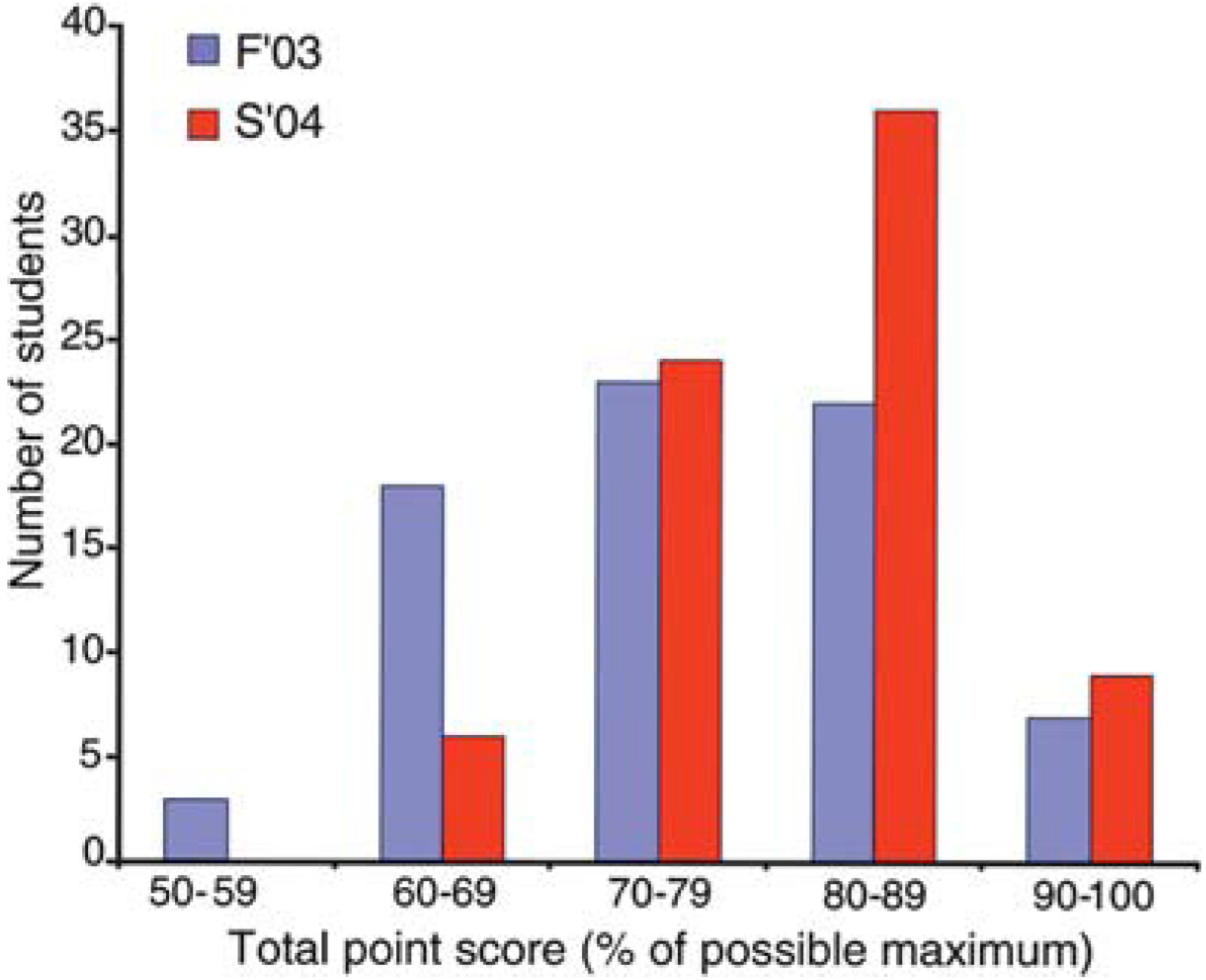


Figure 1. Final course point distributions (% of possible maximum) in traditional (F’03, blue) and interactive (S’04, red) classes. The number of students achieving a final score is shown for five ranges of scores.

Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell Biology Education, 4*(4), 298-310. doi:10.1187/05-06-0082

Efficacy of Active Learning

Percent of Students Earning Final Grades of A, B, and C			
	A	**B**	**C**
Traditional Lecture (Fall 2003)	23%	37%	38%
Interactive Instruction (Spring 2004)	20%	51%	38%

Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell Biology Education, 4*(4), 298-310. doi:10.1187/05-06-0082

Efficacy of Active Learning

Average Percent Normalized Learning Gains by Ethnicity and Gender		
Group	Traditional Lecture (Fall 2003)	Interactive Instruction (Spring 2004)
Minority (male and female)	41 ± 21 (n=17)	56 ± 21 (n=13)
Male	41 ± 32 (n=22)	62 ± 21 (n=31)
Female	51 ± 18 (n=51)	62 ± 21 (n=42)
Total	46 ± 23 (n=73)	62 ± 22 (n=73)

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Efficacy of Active Learning

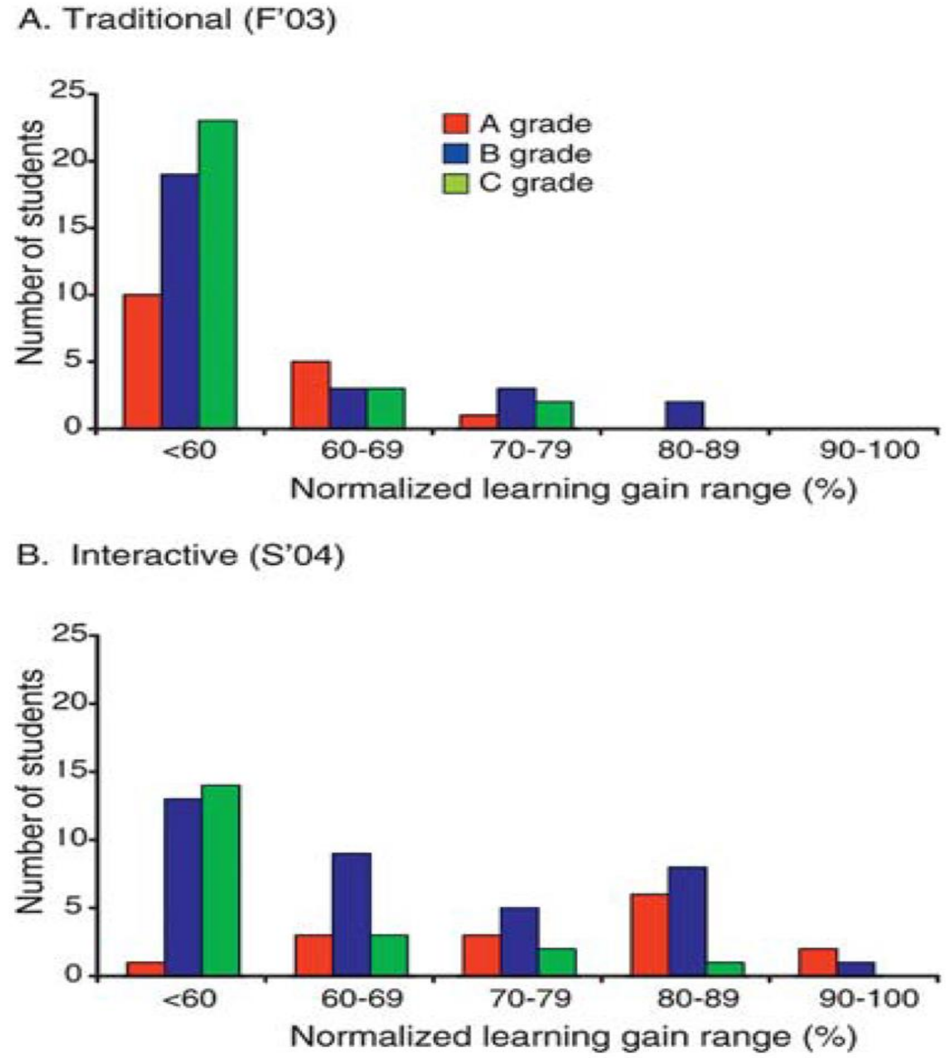

Figure 2. Comparison of normalized learning gain ranges (% of possible maximum) achieved by students in each passing grade range ("A," "B," and "C") in the F′03 and S′04 courses. Normalized learning gains were computed as 100 × (posttest score − pretest score)/(100 − pretest score) (see text). A. F′03 (traditional class). B. S′04 (interactive class).

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Efficacy of Active Learning

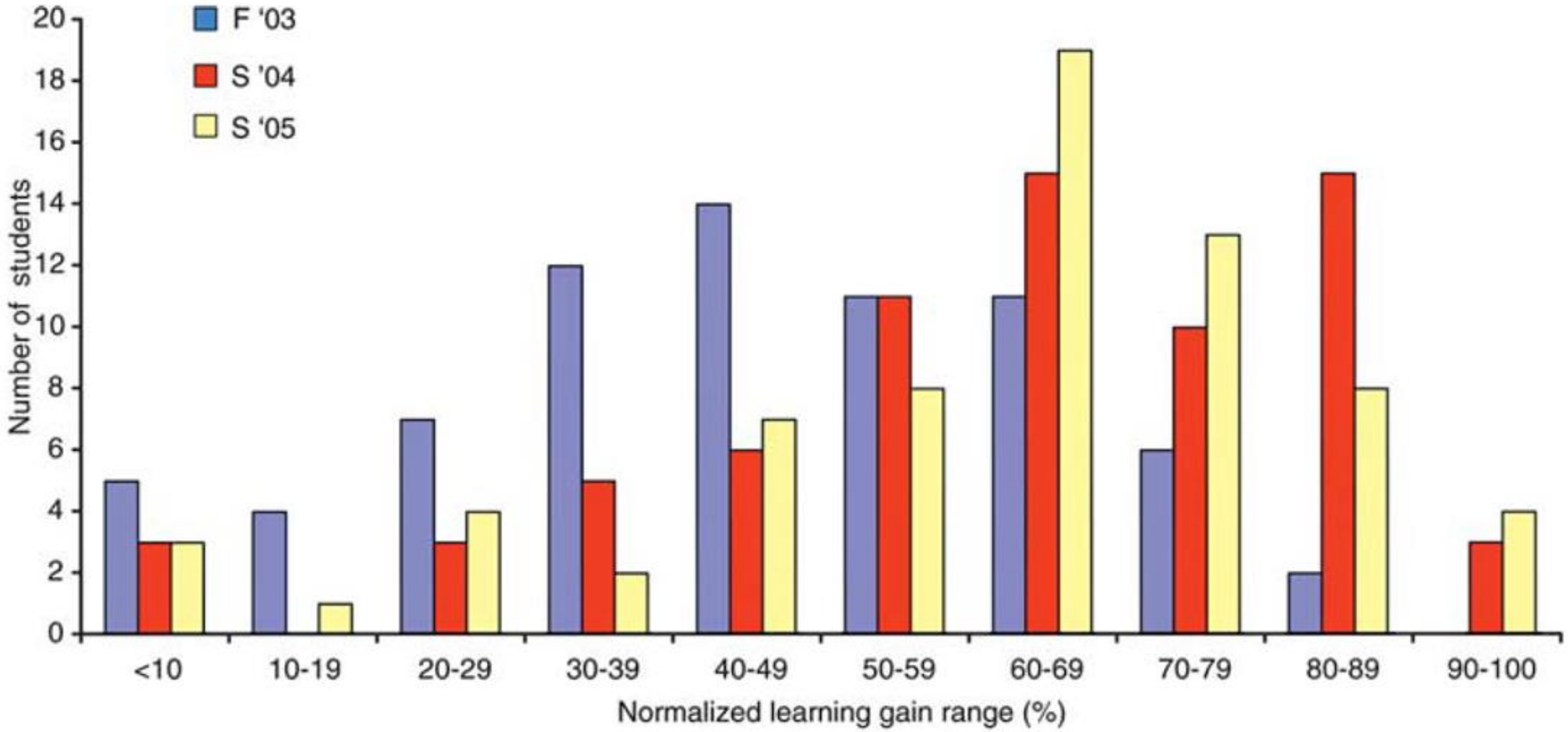

Figure 3. Comparison of normalized learning gains (% of possible maximum) in 10% increments on 12 common pretest and posttest questions for students in one traditional (F'03) and two interactive (S'04, S'05) classes. Normalized learning gains were computed as in Figure 2.

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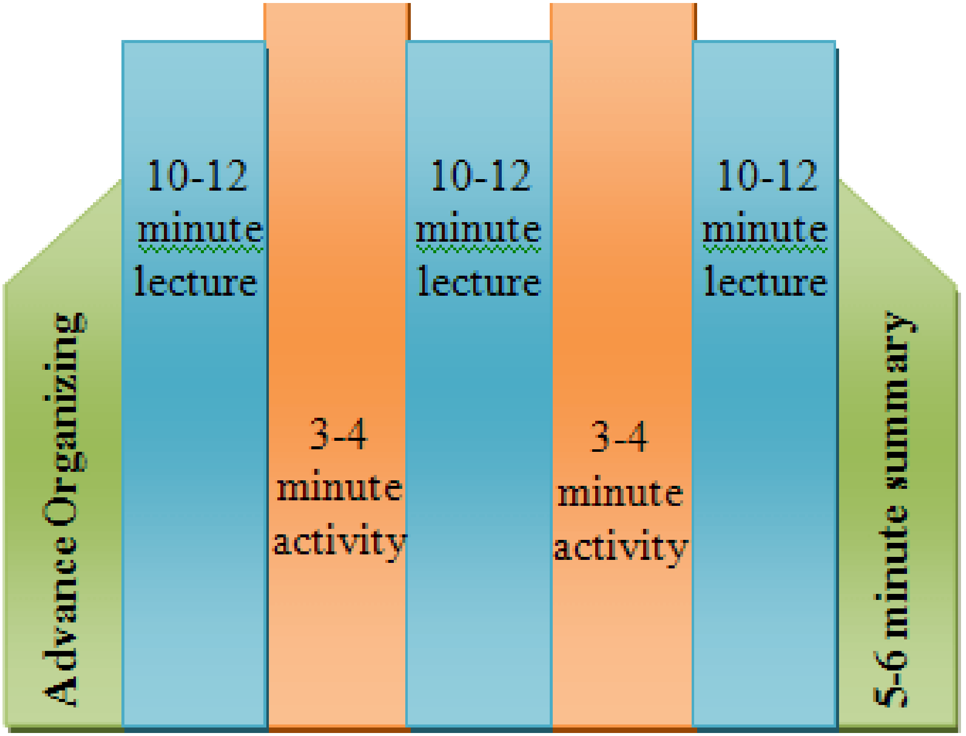
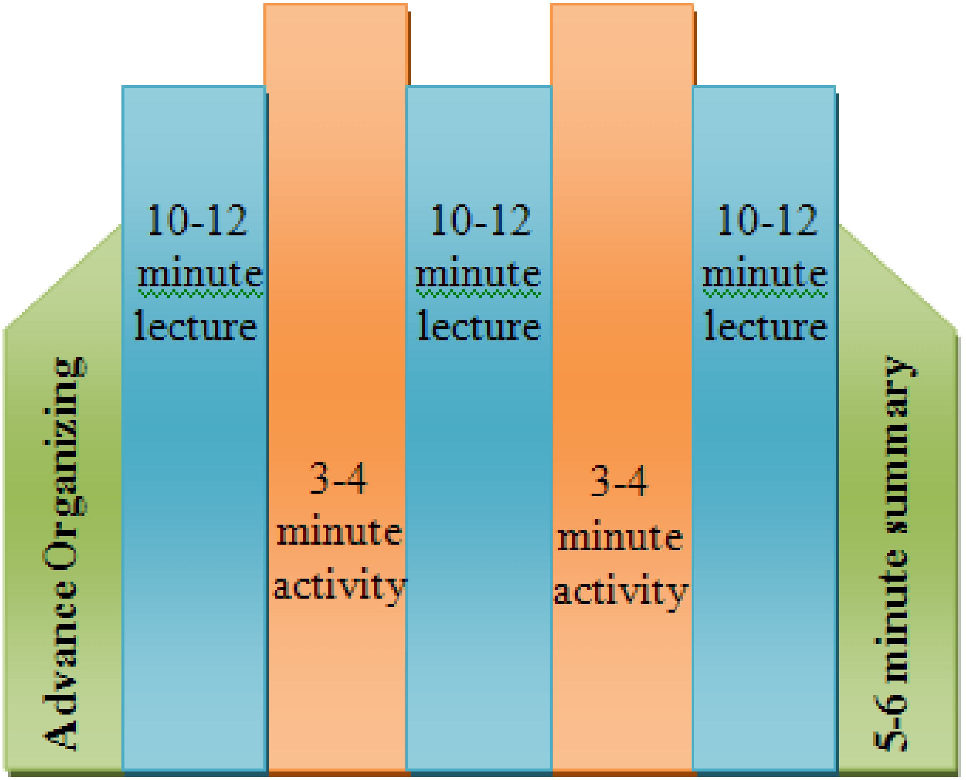


Part 1

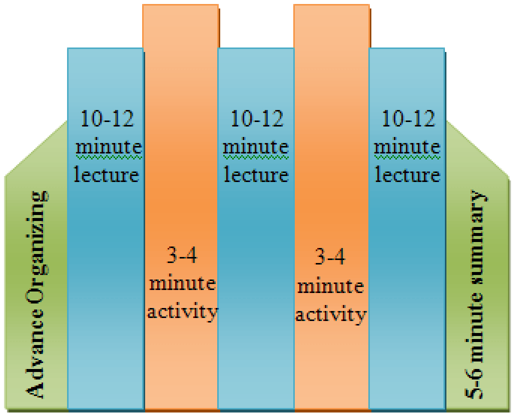
Bookend Lecture Template

Bookend Lecture

- Advanced Organizer
- Lecture (~10-12 minutes)
- Cognitive Processing Activity (~3-4 minutes)
- Lecture (~10-12 minutes)
- Cognitive Processing Activity (~3-4 minutes)
- …
- Summary Processing Activity



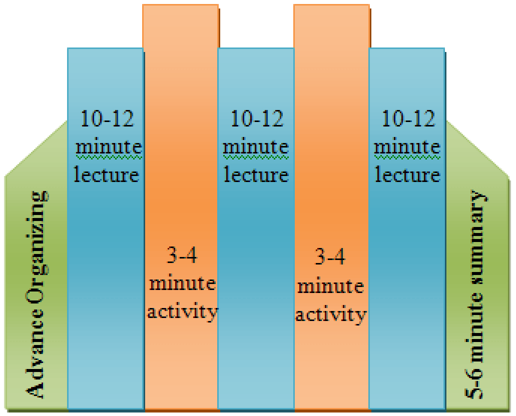
Advance Organizer



Purposes: Prime relevant knowledge. Engage students immediately.

- Example: Reading Quiz
- Example: Application of Lecture Content
- Example: Provocative Question
- Example: Connect with Previous Lecture
- Example: …

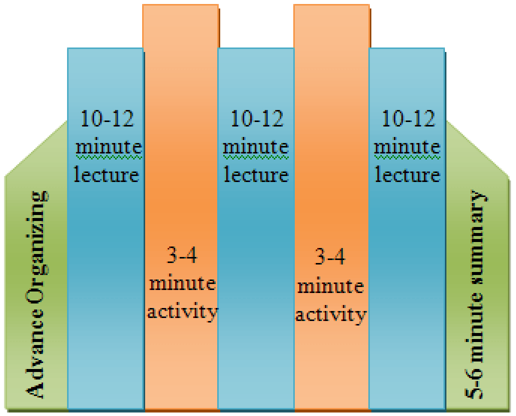
Exercise: Generate ideas for an advance organizer for a lecture



Process

- Think of a course you will be teaching. Pick a lecture in that course
- Write down lecture topic and at least 3 advance organizer ideas
- Share with topics and ideas with a neighbor
- Poll class for ideas

Exercise: Generate ideas for an advance organizer for a lecture



- Refer to Facebook article on house fire related to gas problem – What do you know? How do you relate this event to this course

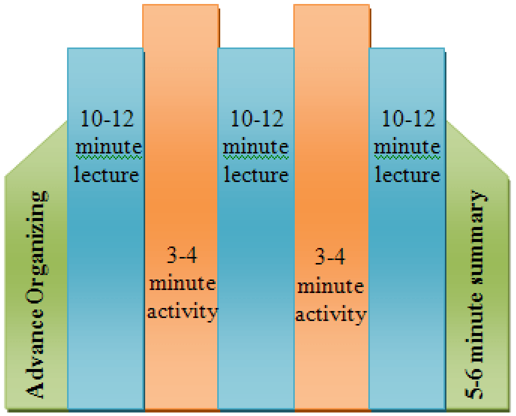
- What is the definition for material?

- True/False quiz on mobile applications & statistics

- How can you tell if an electric motor is stable?

- Antennas – Where do you see antennas in everyday life?

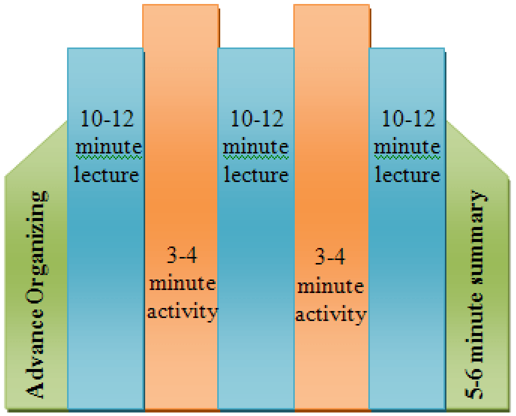
Process Activity



Purpose: Promote student engagement with lecture content.

- Example: Think – Pair - Share
- Example: Clicker question
- Example: Concept question (aka ConcepTests)
- Example: Generate applications of content
- Example: …

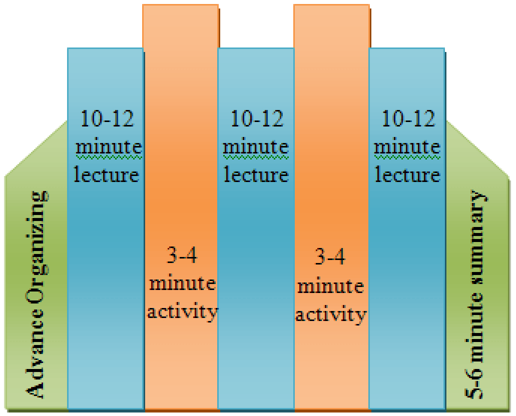
Process Activity



Reason: Learners remember what they retrieve, not what they receive

- Learning Principle: Retrieval Practice
- Learning Principle: Spaced Retrieval Practice
- Evidence: Students remember more of what they receive, if they retrieve it within 10-12 minutes of receiving the information

Process Activity



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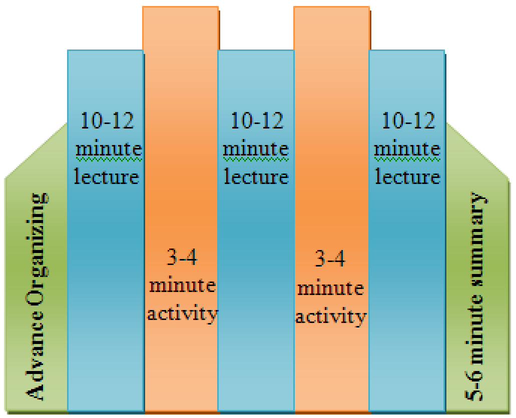
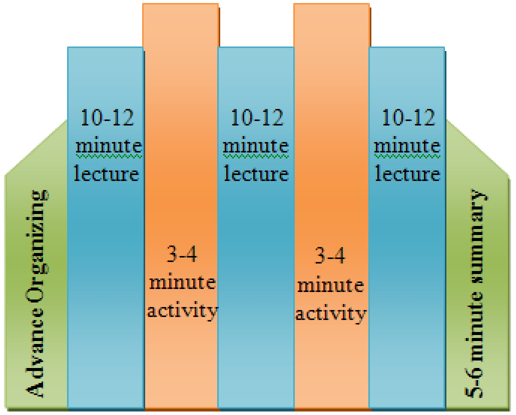


Think – Pair - Share

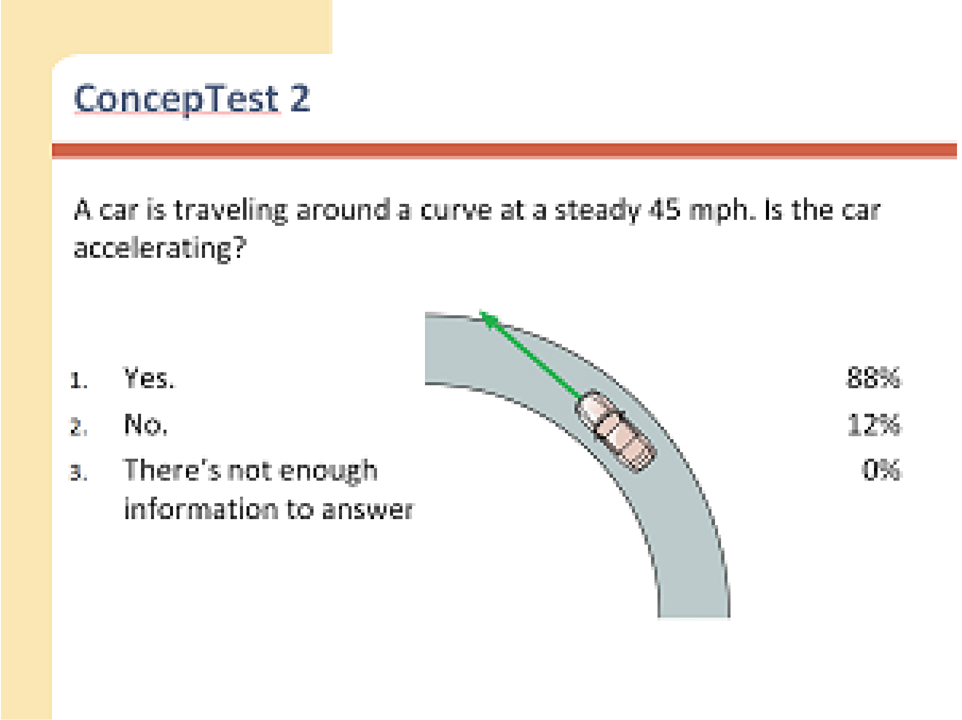
- Ask students to think individually about the prompt for a minute or so
- Ask students to turn to a neighbor and share their answers with each other
- Poll the class for a few answers

Process Activity



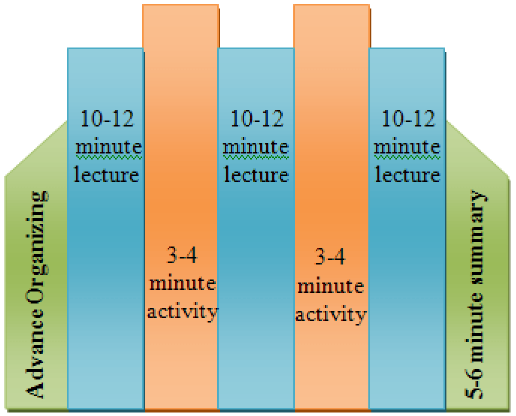
Concept Question (aka ConcepTests)

- A concept question is generally short, almost always multiple-choice, ask students to reason qualitatively about a single concept…



ConcepTests:
https://serc.carleton.edu/introgeo/interactive/conctest.html

Exercise: Generate ideas for a process activity in a lecture



Process

- Think of a course you will be teaching. Pick a lecture in that course
- Write down lecture topic and at least 3 process activity ideas
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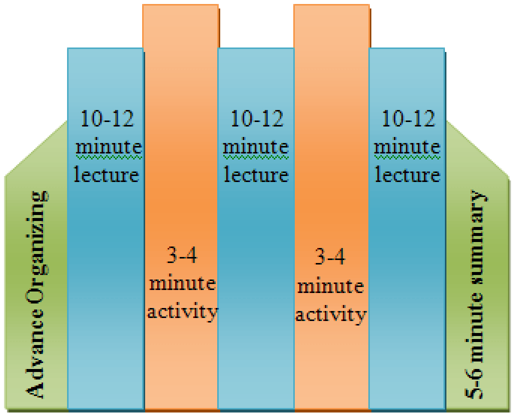
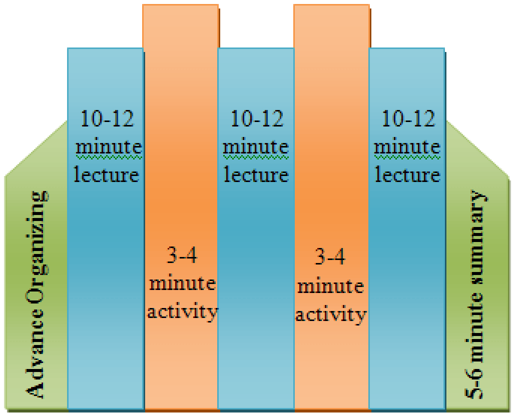
- Poll class for ideas

Exercise: Generate ideas for an process activity in a lecture



- What types of risks in construction?
- Quiz and prize for 1st correct answer
- What will happen if this factor changes?
- Arrange a debate (Yes/No)
- Show a page with an error, find the error

Summary Activity



Purpose: Process main ideas from the lecture

- Example: Minute paper
- Example: Plus / Delta
- Example: Classroom Assessment Technique

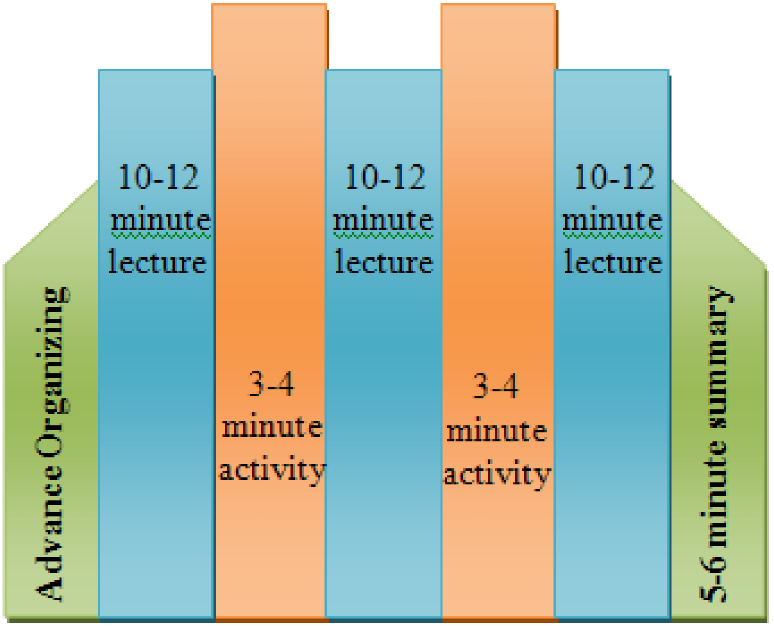
Minute Paper

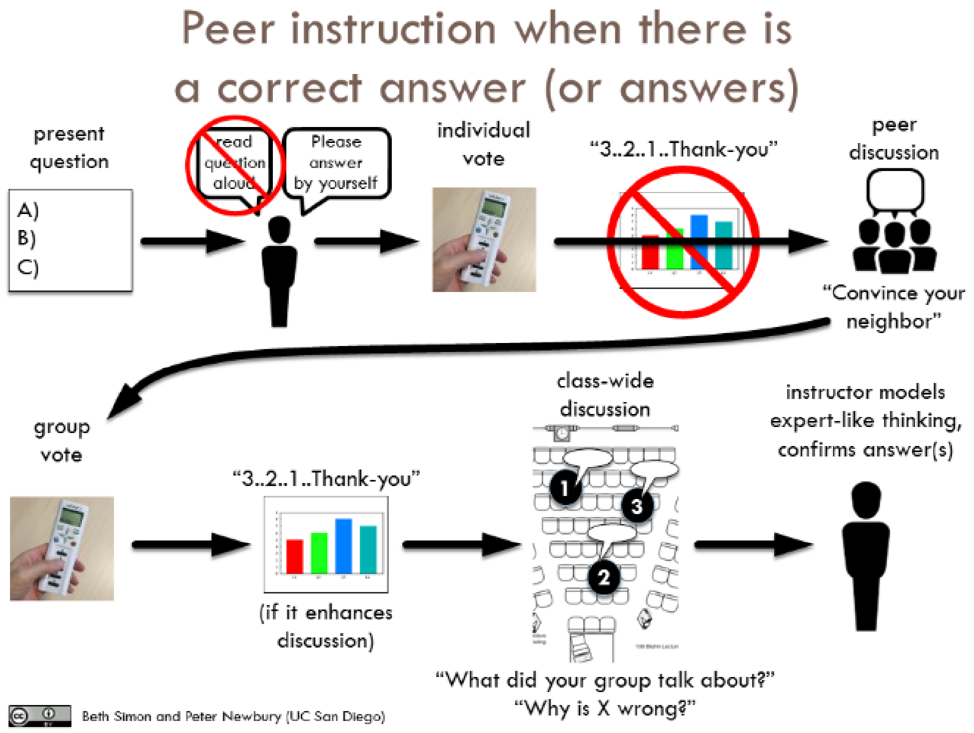
At the end of each class period, write brief answers to the following questions:

- What is most valuable or helpful idea or concept that you learned today?
- What is the “muddiest or most confusing point” about in today’s lecture?

Bookend Lecture: Exercise

- Think of a course you will be teaching. Think of a specific lecture in that course.
- Design a bookend lecture for that lecture
  - Advance Organizer
  - 2-3 Process Activities
  - Summary Activity

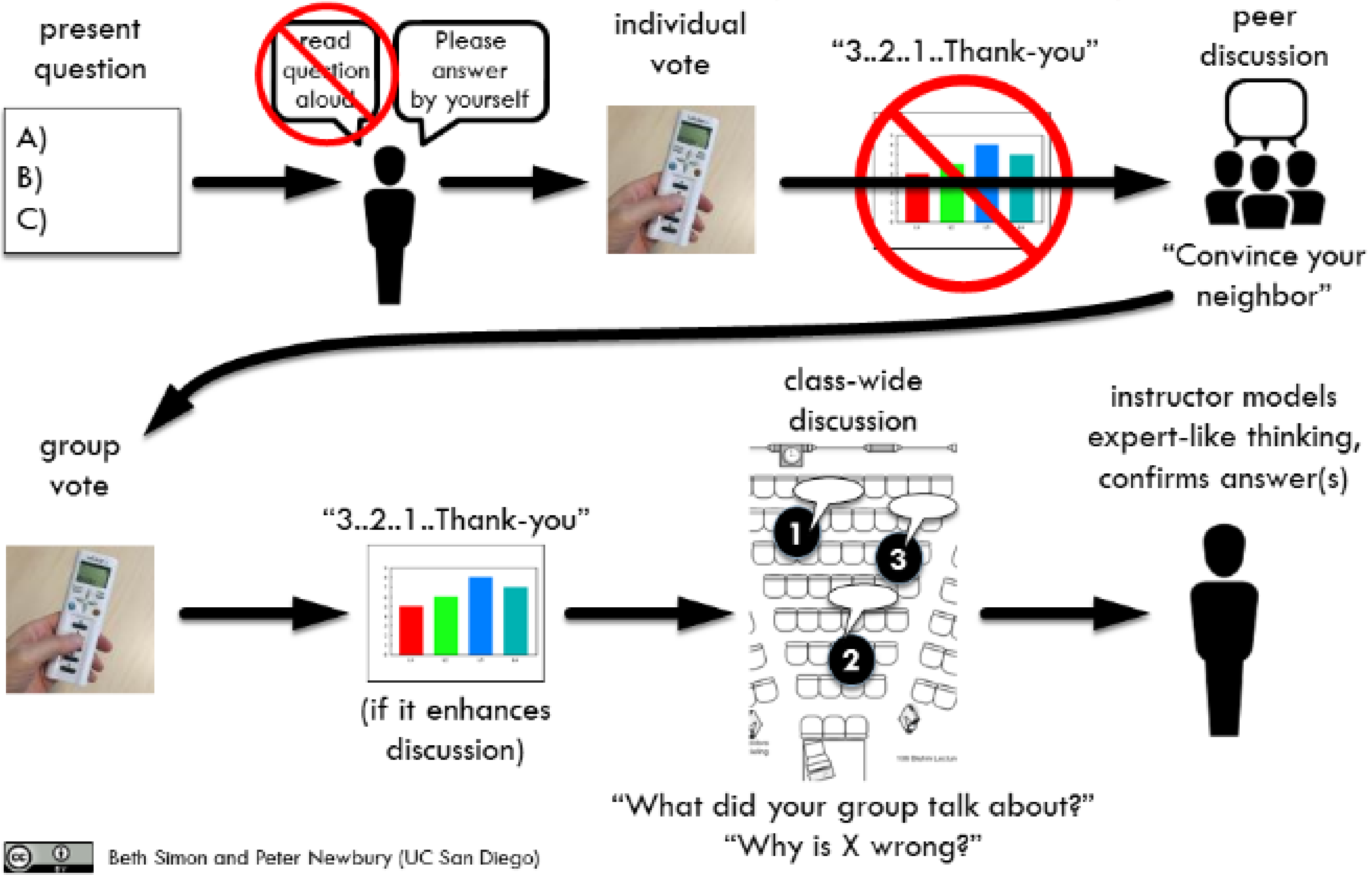




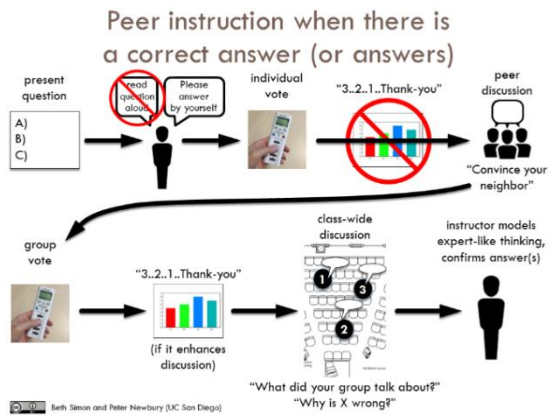
Part 2

Peer Instruction™

Peer instruction when there is a correct answer (or answers)

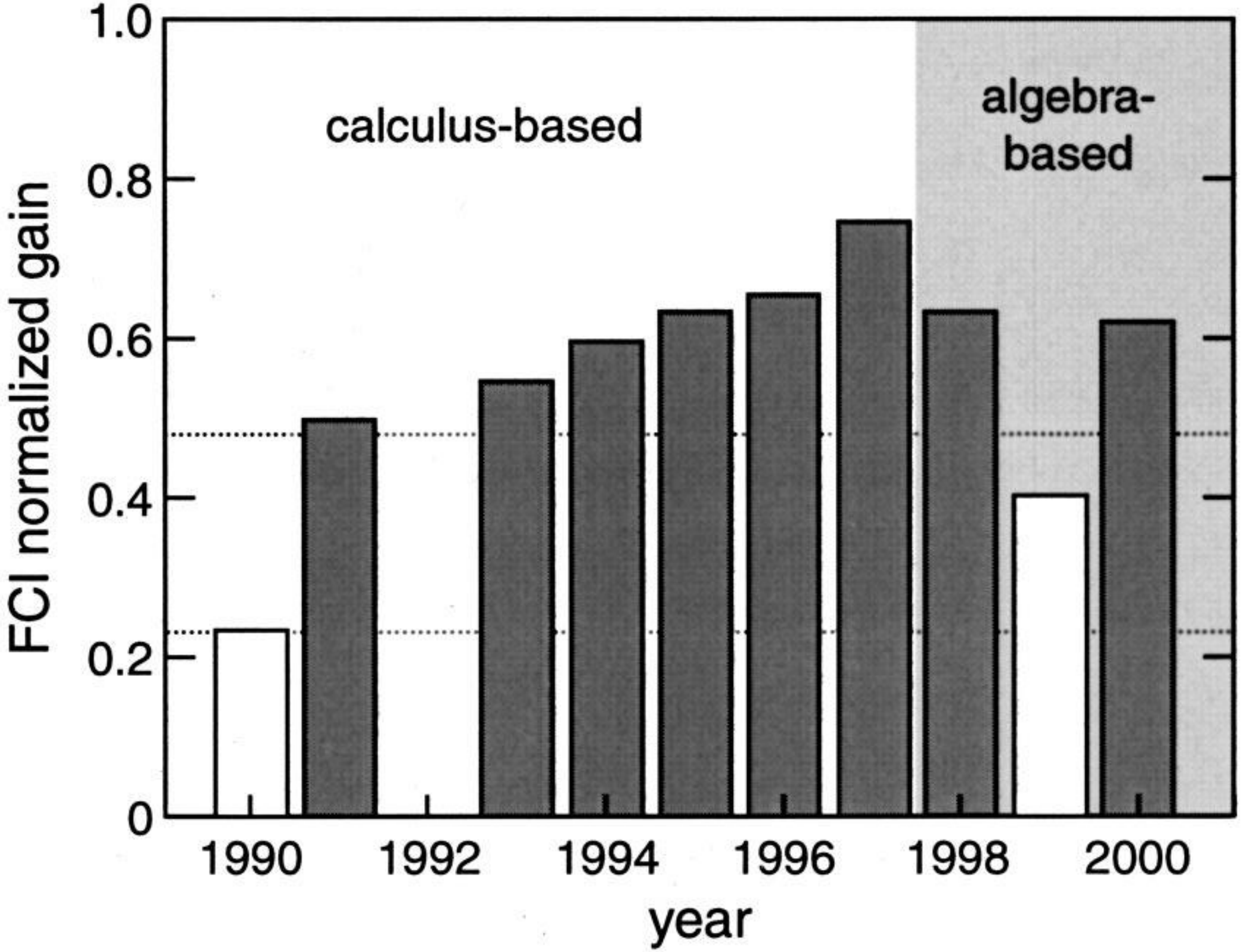


Peer Instruction™



- Peer Instruction was first devised and popularized by Eric Mazur a professor in physics as Harvard University
- It has widely adopted by physics faculty members.
- It has been developed and adopted in biology, chemistry, engineering, computer science…

Why Peer Instruction™?



Average Force Concept Inventory normalized gain for introductory calculus-based physics, Harvard University, Fall 1990–Fall 1997, and for introductory algebra-based physics, Harvard University, Fall 1998–Fall 2000. Open bars indicate traditionally taught courses and filled bars indicate courses taught with PI [peer instruction]. Dotted lines correspond to <g> = 0.23, the typical gain for a traditionally taught course, and <g> = 0.48, the typical gain for an interactive course (Hake).

Peer Instruction (Eric Mazur)

- Resources:
  - Mazur, Eric. (1997). *Peer instruction: A user's manual*. Englewood Cliffs, NJ: Prentice Hall.
  - Crouch, Catherine H., & Mazur, Eric. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970-977. doi:10.1119/1.1374249
  - http://mazur.harvard.edu/research/detailspage.php?rowid=8
  - http://www.physics.umd.edu/perg/role/PIProbs/
  - AIChE Concept Warehouse: https://jimi.cbee.oregonstate.edu/concept_warehouse/

Part i

Effective Principles for Learning

Effective Principles for Learning		Low-performing Practices for Learning
Retrieval	**Metacognition**	
Retrieval	Calibration	Highlighting
Spaced Retrieval	Reflection	Rereading
Interleaved Retrieval	Self-explanation	Summarization
Generative Practice	Planning, Monitoring, Evaluating, Revising	Imagery Use for Text Learning
Elaboration		Keyword Mnemonic

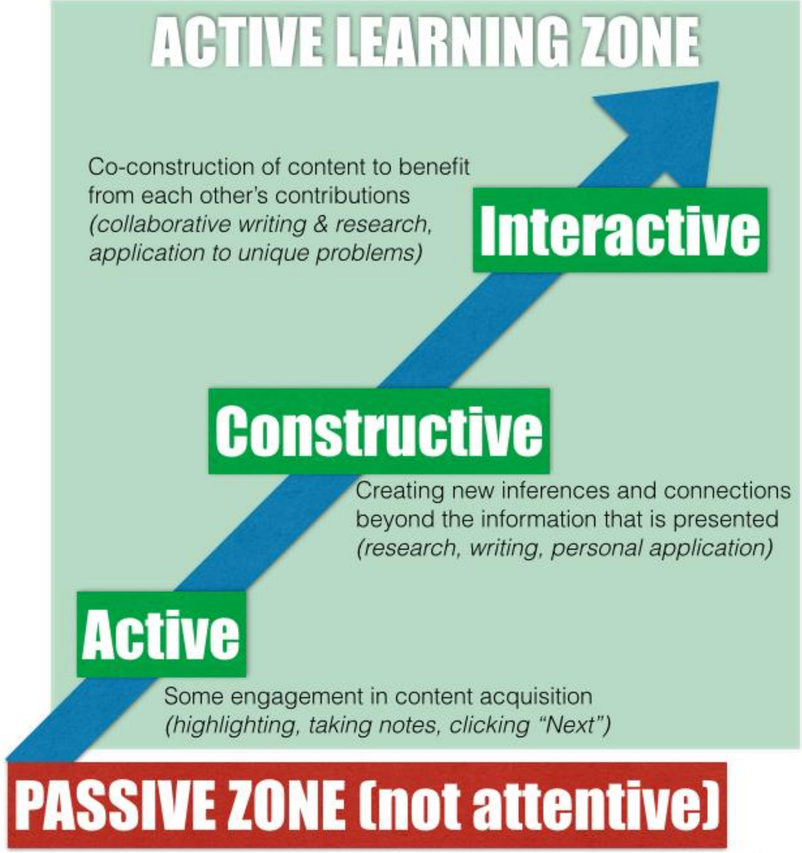
Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*(1), 4-58. https://doi.org/10.1177/1529100612453266

People do not learn what they receive.

People learn what they **retrieve**.

Accessible Resources on Research on Learning

- Learning Scientists, https://www.learningscientists.org/
- **Interleaved Practice:** The "one quick trick" of learning principles: interleaved practice by Benjamin Keep, https://www.benjaminkeep.com/blog/the-one-quick-trick-of-learning-principles-interleaved-practice
- **Spaced Practice:** The spaced practice effect: what it is and how to leverage it by Benjamin Keep, https://www.benjaminkeep.com/blog/the-spaced-practice-effect-what-it-is-and-how-to-leverage-it
- **Cognitive Load:** Make Working Memory Work For You by Benjamin Keep, https://www.benjaminkeep.com/blog/make-working-memory-work-for-you
- **Retrieval:** The Wicked Effectiveness of Retrieval Practice by Benjamin Keep, https://www.benjaminkeep.com/blog/the-wicked-effectiveness-of-retrieval-practice
- **Elaboration:** Let Me Elaborate... On A Way To Improve Memory by Benjamin Keep, https://www.benjaminkeep.com/blog/let-me-elaborate-on-a-way-to-improve-memory
- **Learning and Teaching:** Why Learning Science Fails to Make Its Way Into Practice, by Benjamin Keep, https://www.benjaminkeep.com/blog/why-learning-science-fails-to-make-its-way-into-practice



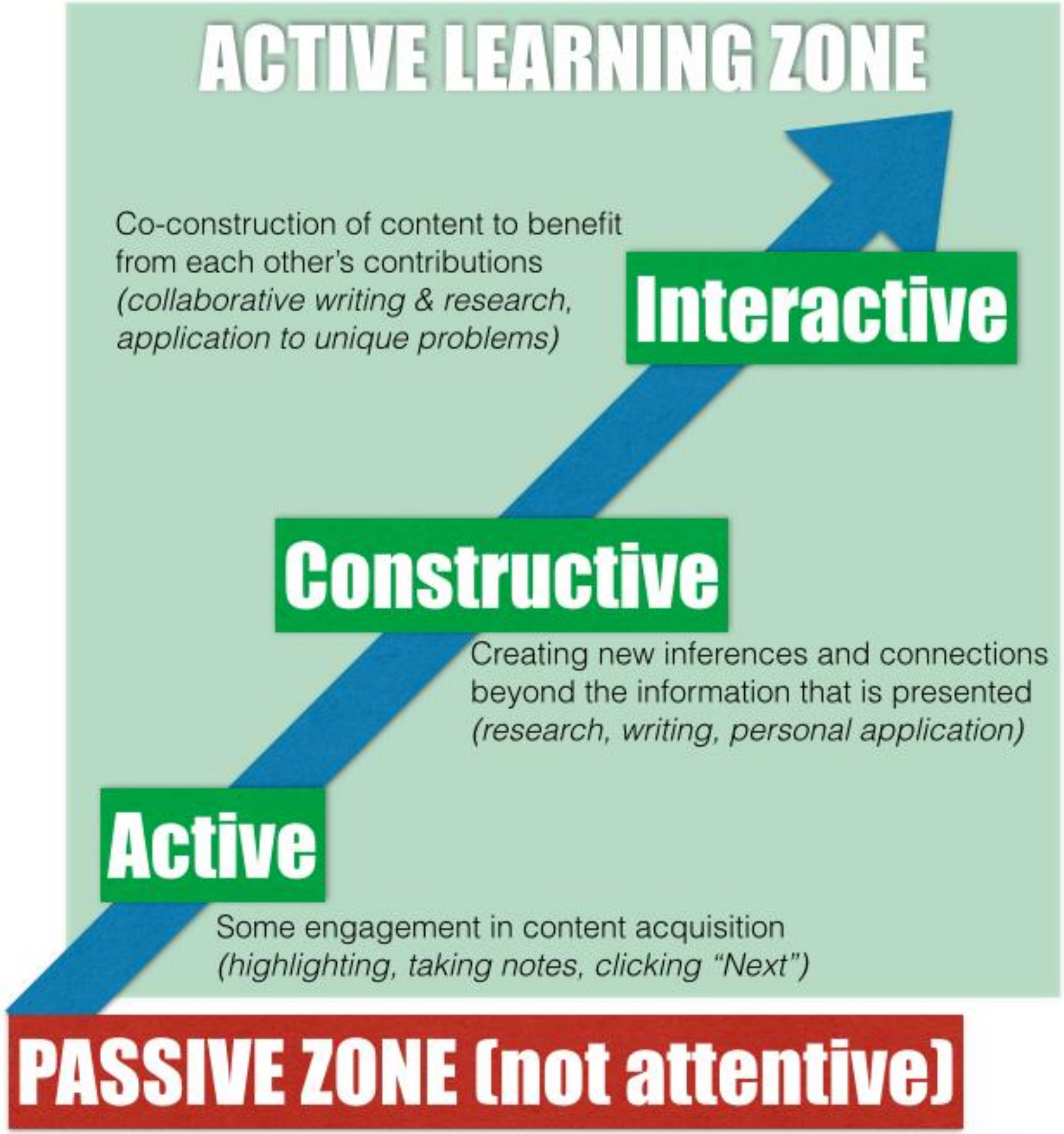
Chi, M. T. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. Topics in Cognitive Science, 1(1), 73-105.

Part 3

Differentiated Overt Learning Activities Framework

Differentiated Overt Learning Activities Framework

- Passive
- Active
- Constructive
- Interactive



Chi, M. T. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. Topics in Cognitive Science, 1(1), 73-105.

Passive

- Concept
  - Receive information
- Examples
  - Listening to lecture
  - Taking lecture notes by copying what is on the board

Menekse, M., Stump, G. S., Krause, S., & Chi, M. T. H. (2013). Differentiated overt learning activities for effective instruction in engineering classrooms. *Journal of Engineering Education, 102*(3), 346-374. doi: 10.1002/jee.20021.

Active

- **Cognitive Processes**
  - Activate their own knowledge related to desired content
  - Search for new knowledge related to desired content
  - Emphasizing selected passages
- **Examples**
  - Following procedure of a highly structured experiment
  - Repeating sentences out loud after hearing them
  - Underlining or highlighting some sentences while reading
  - Copying solution of a problem from the board while the teacher is solving it (?)
  - Selecting from a list of choices as in matching tasks
  - Looking and searching for specific information in a text or problem
  - Playing a video game without making strategic decisions
- **Students do something or manipulate instructional information overtly**

Menekse, M., Stump, G. S., Krause, S., & Chi, M. T. H. (2013). Differentiated overt learning activities for effective instruction in engineering classrooms. *Journal of Engineering Education, 102*(3), 346-374. doi: 10.1002/jee.20021.

Constructive

- **Cognitive Processes**
    - Generate knowledge that extends beyond the presented materials
- **Contrast**
    - Active: Simply repeating a paragraph or underlining text
    - Constructive: Self-explaining or explaining aloud to oneself a concept
- **Examples**
    - Converting text-based information into symbolic notation, e.g., drawing a concept map, drawing and interpreting graphs
    - Putting into one's own words., e.g., taking lecture notes in one's own words, generating self-explanations
    - Comparing and contrasting different situations
    - Generating examples from daily lives
    - Making strategic decisions in a video game

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Constructive: Examples

- Converting text-based information into symbolic notation, e.g., drawing a concept map, drawing and interpreting graphs
- Putting into one's own words., e.g., taking lecture notes in one's own words, generating self-explanations
- Comparing and contrasting different situations
- Generating examples from daily lives
- Making strategic decisions in a video game
- Asking comprehension questions
- Monitoring one's comprehension
- Solving a problem that requires constructing knowledge
- Justifying claims with evidence
- Designing a study
- Posing a research question
- Using analogy to describe certain cases
- Hypothesizing and testing an idea

Menekse, M., Stump, G. S., Krause, S., & Chi, M. T. H. (2013). Differentiated overt learning activities for effective instruction in engineering classrooms. *Journal of Engineering Education, 102*(3), 346-374. doi: 10.1002/jee.20021.

Interactive

- **Description**
  - Two or more learners undertaking constructive learning activities
- **Cognitive Processes**
  - Interaction of the learners further enables them to build upon one another’s understanding
  - Interaction between learners affords them the benefit of receiving feedback or prompting from each other, with each partner having some complementary knowledge or perspectives
- **Examples**
  - Studying or working in pairs or groups
  - Reciprocal teaching
  - Interacting with feedback from a teacher, an expert, or a computer agent
  - Arguing or defending one’s position with evidence

Menekse, M., Stump, G. S., Krause, S., & Chi, M. T. H. (2013). Differentiated overt learning activities for effective instruction in engineering classrooms. *Journal of Engineering Education, 102*(3), 346-374. doi: 10.1002/jee.20021.

Exercise: Differentiating Overt Learning Activities Framework

Think of a course you have taught. Think of a lecture in that course. Write down what students were doing during that lecture in each of the four categories of the framework.

Passive	
Active	
Constructive	
Interactive	

ICAP Hypothesis

I > C > A > P

Traditional Instructional Strategy	Differentiated Overt Learning Activities Framework			
	Passive	Active	Constructive	Interactive
Students learning before class	?			
Students learning during class	X	X		
Students learning after class			X	

Flipped Instructional Strategy	Differentiated Overt Learning Activities Framework			
	Passive	Active	Constructive	Interactive
Students learning before class	X	X		
Students learning during class	?	?	?	?
Students learning after class			X	

ICAP Exercise

- Think of a course you will be teaching. Pick a lecture in that course
- Redesign the lecture applying what you have learned about Interactive – Constructive – Active – Passive learning
- Share with topics and ideas with a neighbor
- Poll class for ideas

Generate at least five ideas for incorporating research on the Passive-Active-Constructive-Interactive framework to help your students learn problem solving in your course.

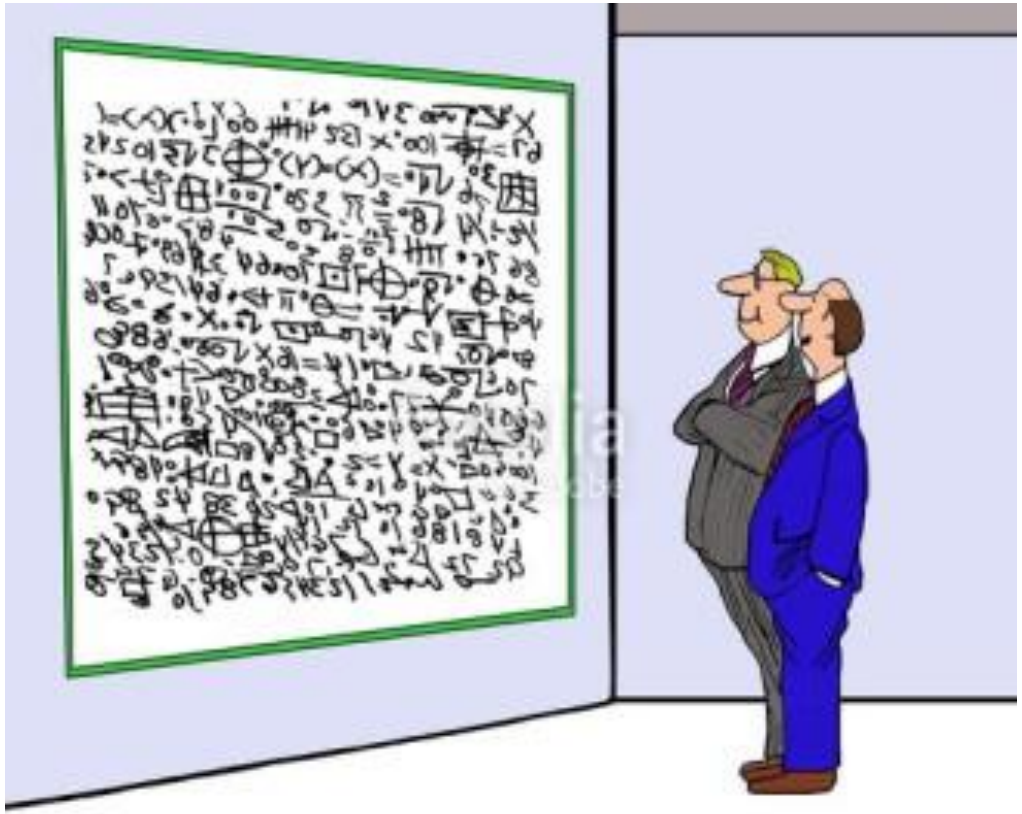
Please write down your questions individually

References: Differentiated Overt Learning Activities Framework

Chi, M. T. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science, 1*(1), 73-105. https://dx.doi.org/10.1111/j.1756-8765.2008.01005.x

Chi, M. T., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219-243. https://dx.doi.org/10.1080/00461520.2014.965823

Menekse, M., Stump, G. S., Krause, S., & Chi, M. T. (2013). Differentiated overt learning activities for effective instruction in engineering classrooms. *Journal of Engineering Education, 102*(3), 346-374. https://dx.doi.org/10.1002/jee.20021



"When you put it like that, it makes complete sense."

Part 4

Worked Examples

Worked Examples

- Undergraduate engineering courses teach a considerable number of procedures for computing values
- Exams for these courses have multiple problems in which students are expected to compute values for specific configurations.
- Faculty give concrete examples of these procedures as they work examples in class

Worked Examples

Literature on Worked Examples / Example-based Learning

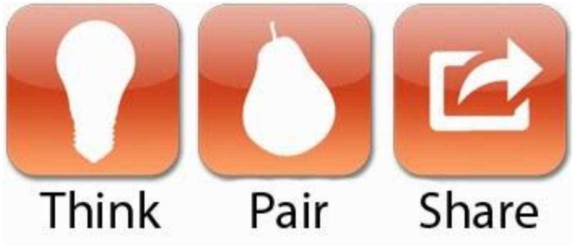
- **Approach 1 - Problem Solving:** Give students problems and let them worked on them
- **Approach 2 - Worked Examples:** Give students examples in which problems have been solved and let them review.
- **Approach 3 - Worked Examples with Fading:** Give students examples in which problems have been solved, but with steps missing, and let them review and fill in the missing steps
- **Approach 4 - Instructional Examples:** Faculty member shows the students step-by-step how to solve the examples.

Worked Examples

Combinations of approaches (2), (3), and (1) have been shown to be most effective

- **Approach 1 - Problem Solving**
- **Approach 2 - Worked Examples**
- **Approach 3 - Worked Examples with Fading**
- **Approach 4 - Instructional Examples**

Generate at least five ideas for incorporating research on worked examples to help your students learn problem solving in your course.



Please write down your questions individually

References: Research on Worked Examples

- Van Gog, T., Paas, F., & Van Merriënboer, J. J. (2008). Effects of studying sequences of process-oriented and product-oriented worked examples on troubleshooting transfer efficiency. *Learning and Instruction, 18*(3), 211-222. https://doi.org/10.1016/j.learninstruc.2007.03.003
- Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research, 70*(2), 181-214. https://doi.org/10.3102/00346543070002181
- Van Merrienboer, J. J., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review, 17*(2), 147-177. https://doi.org/10.1007/s10648-005-3951-0

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Part X

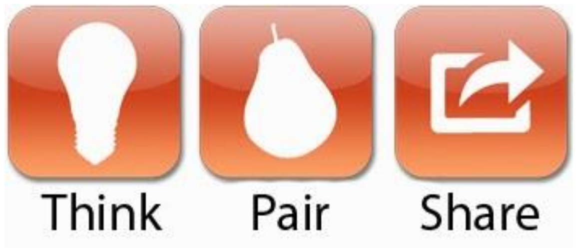
Engaging Student Resistance

Engaging Student Resistance

- Student Resistance: What does it look like?
- Student Resistance: General Advice
- Student Resistance: Explanation Strategies
- Student Resistance: Facilitation Strategies

Understanding Student Resistance to Active Learning
https://www.teachingprofessor.com/topics/teaching-strategies/active-learning/student-resistance-active-learning/

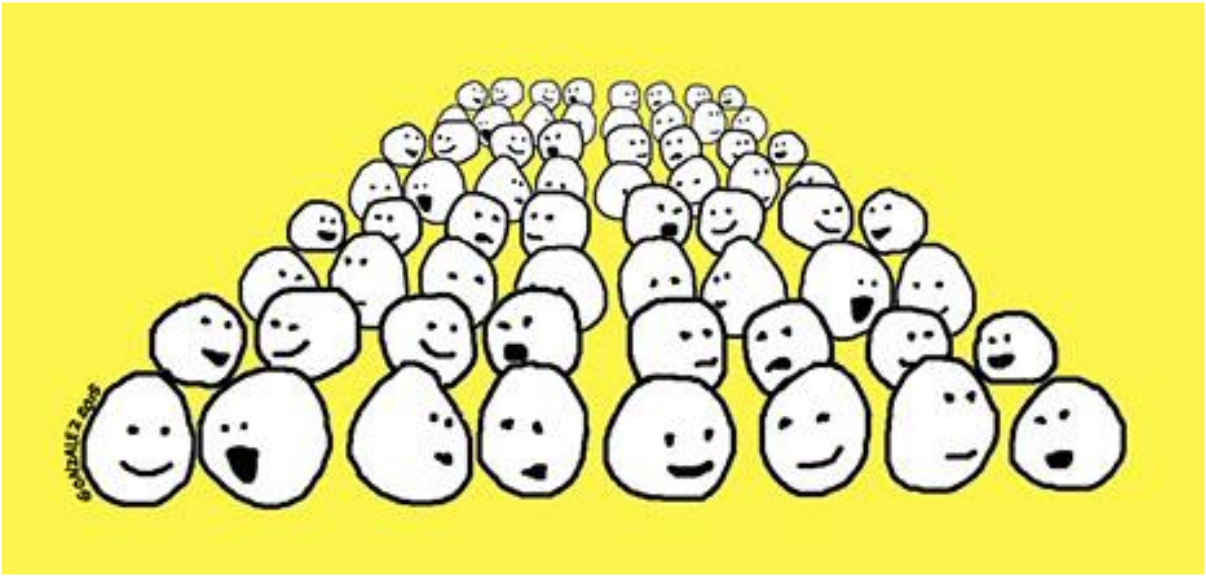
What should faculty members expect to see from students when they engage in instructional strategies that use active learning?



Please write down your responses individually

What should faculty members expect to see from students when they engage in instructional strategies that use active learning?

Please turn to your neighbor and exchange answers.



Student Resistance

- Please share your answers with the group

Sources of Student Resistance to Active Learning

- Something is Different
- Confusion
- Anxiety
- Classroom Participation Norms

Addressing Student Resistance

- Resistance to externally-induced change is **inevitable**.
- Students are confused or anxious about responding to requests to engage in activities
- Students refuse to engage in active learning activities
- Students write negative comments on end-of-course evaluations
- Student responses differ: Some students will readily engage and enjoy it. Some students will be reticent. Some students will refuse to engage.

Addressing Student Resistance

- Resistance to externally-induced change is **inevitable**. Anticipate and prepare.
- Acknowledge changes and accompanying anxiety
- Emphasize benefits and fun. Lots on research on benefits of student engagement and active/cooperative learning.
- Plan to solicit feedback and respond constructively
- Encourage students to visit with you about their doubts
- Plan to talk one-on-one to most visibly anxious students

Felder, R. M. and R. Brent (1996). "Navigating the Bumpy Road to Student–Centered Instruction." College Teaching **44**(2): 43–47.
Felder, R. M. and R. Brent (1994). Cooperative learning in technical courses: Procedures, pitfalls, and payoffs, ERIC Document Reproduction Service Report ED 377038. Washington, DC.
Cooper, J. L., J. MacGregor, et al. (2000). "Implementing Small-Group Instruction: Insights from Successful Practitioners." New Directions in Teaching and Learning **81**: 64-76.

Addressing Student Resistance: Explanation Available Strategies

- Clearly explained the purpose of the activities
- Discussed how the activities related to my learning
- Clearly explained what I was expected to do for the activities

Finelli, C. J., Nguyen, K., DeMonbrun, M., Borrego, M., Prince, M. J., Husman, J., Henderson, C., Shekhar, P., & Waters, C. K. (2019). Reducing student resistance to active learning: Strategies for instructors. *Journal of College Science Teaching, 47*(5), 80-91.

Addressing Student Resistance: Facilitation Available Strategies

- Encourage students to engage with the activities through his/her demeanor
- **Invite students to ask questions about the activities**
- Walk around the room to assist me or my group with the activities, if needed
- Confront students who were not participating in the activities
- **Solicit my feedback or that of other students about the activities**

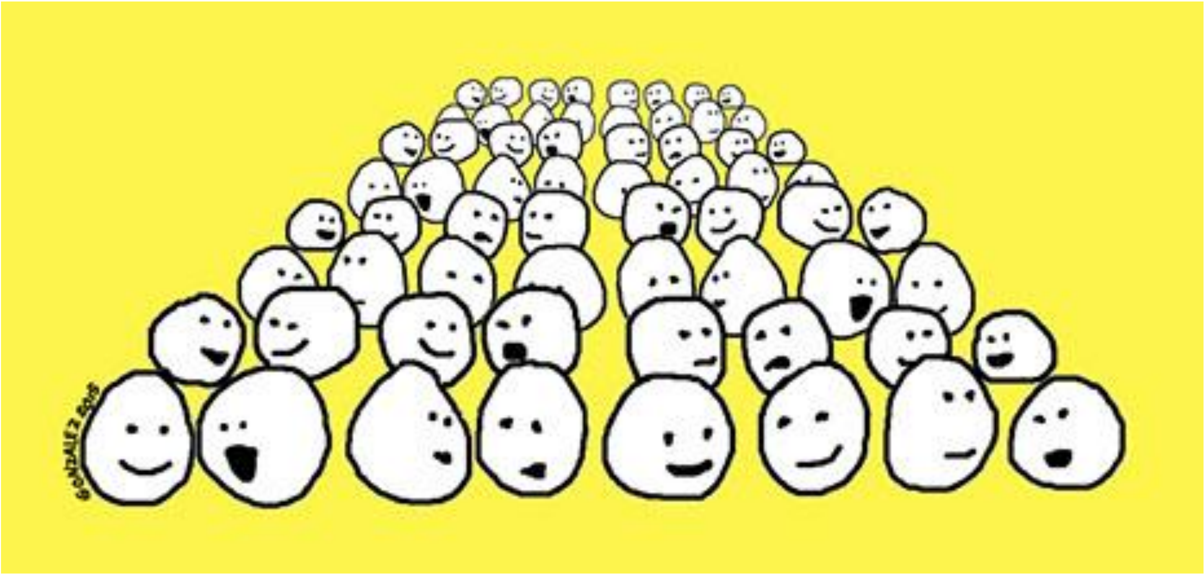
Finelli, C. J., Nguyen, K., DeMonbrun, M., Borrego, M., Prince, M. J., Husman, J., Henderson, C., Shekhar, P., & Waters, C. K. (2019). Reducing student resistance to active learning: Strategies for instructors. *Journal of College Science Teaching, 47*(5), 80-91.

What strategies will I employ to engage student resistance to evidence-based teaching strategies?

Please write down your responses individually

What strategies will I employ to engage student resistance to evidence-based teaching strategies?

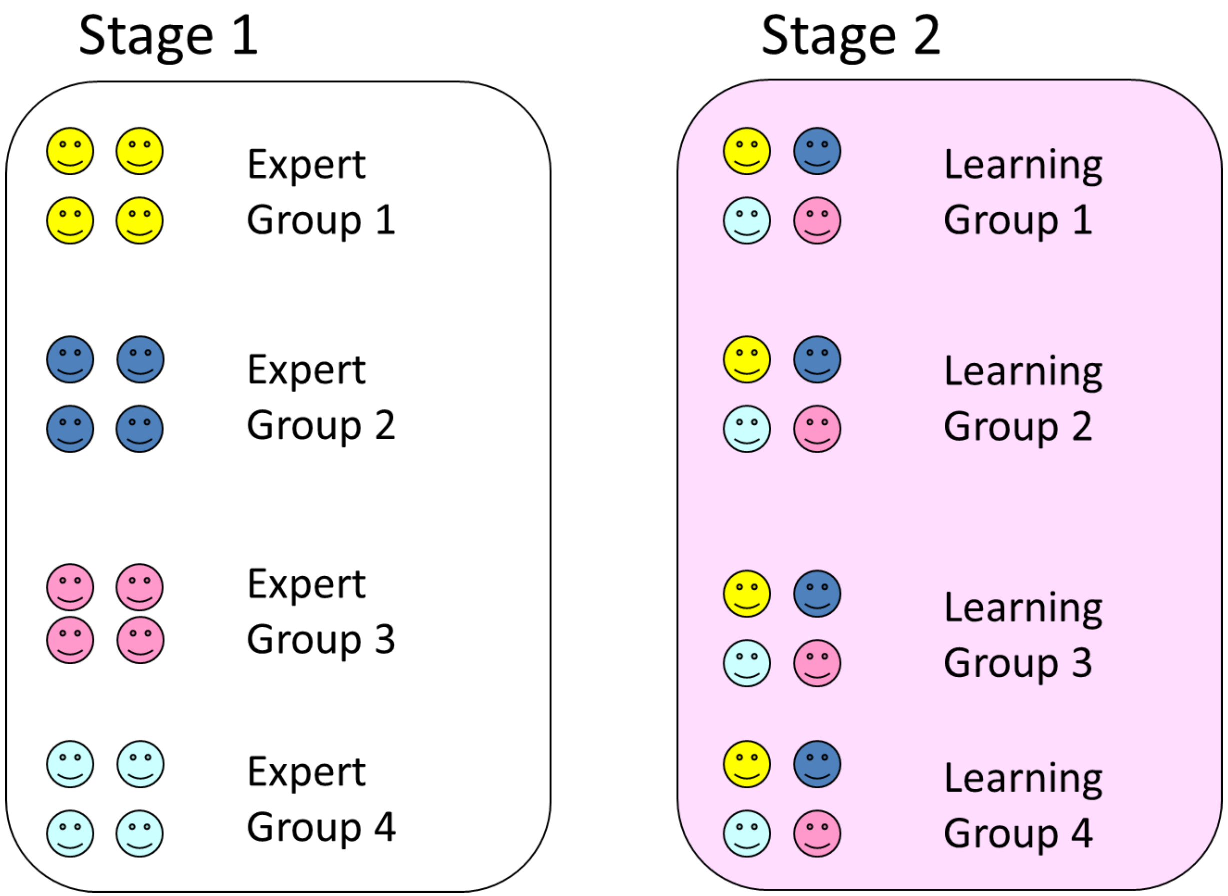
Please turn to your neighbor and exchange answers.



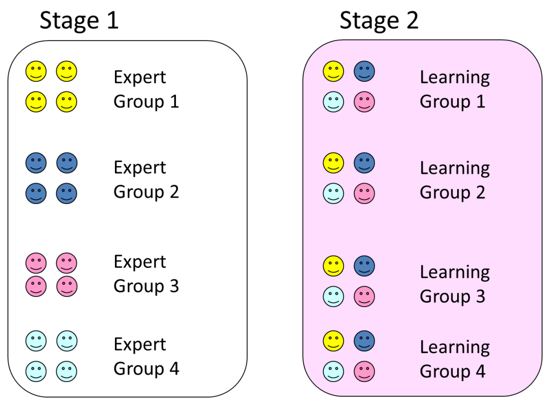
Student Resistance

- Please share your answers with the group

Part 5
Jigsaw

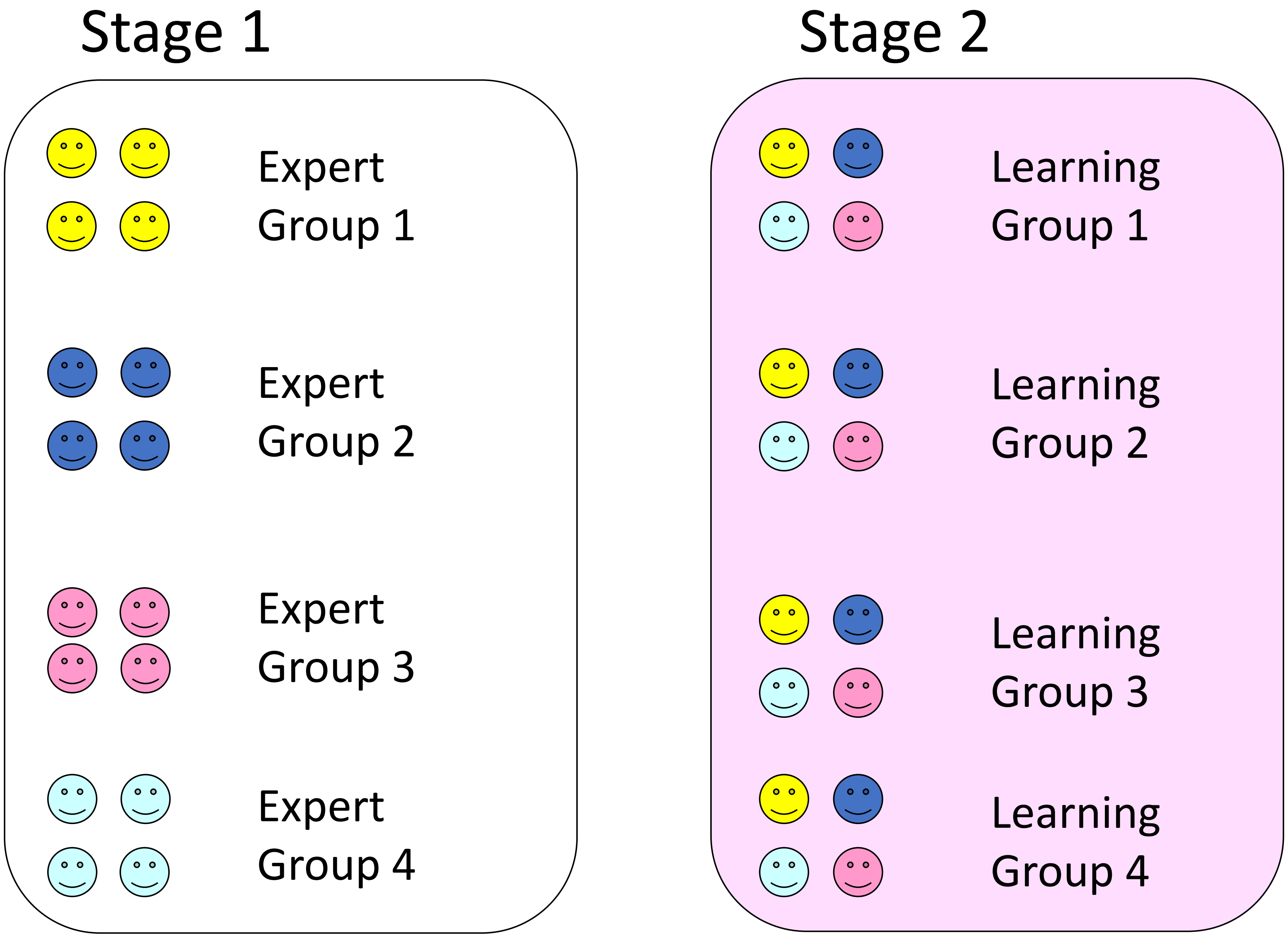


Jigsaw

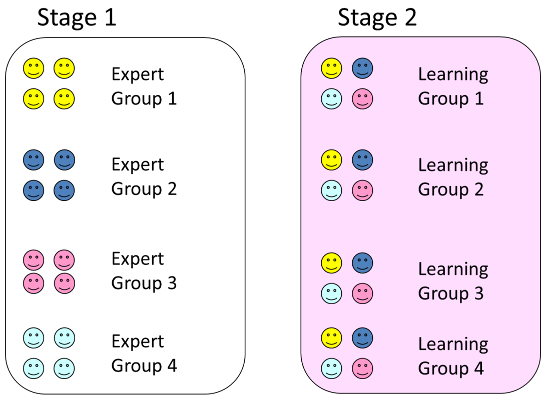


- Jigsaw is an instructional strategy based on generative learning, specifically, learners learn effectively when they have to teach others what they are learning.
- Jigsaw has been and can be adopted in many engineering courses. It does not have to be used for the entire course, it can be used for one or more course segments.
- For many faculty members, jigsaw is a completely different instructional approach that requires adjustment and practice.

Jigsaw: How it works

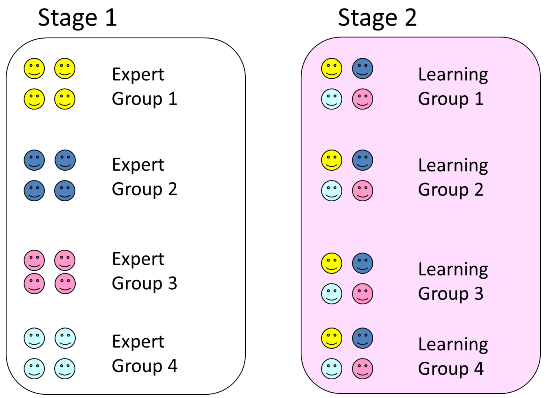


Jigsaw: How it works



- **Stage 1**
  - Each expert group learns an assigned segment and prepares to teach it to the others
- **Stage 2**
  - Each learning group has xx experts who teach their segments to the group

Jigsaw



- Break material to be covered into 4-5 different topics
- Create groups of students assigned to each topic. Each group will work so its members become experts on the assigned topic.
- Create new groups of 4-5 which contain one member from each expert group. New groups teach each other about the 4-5 topic.

http://www.jigsaw.org

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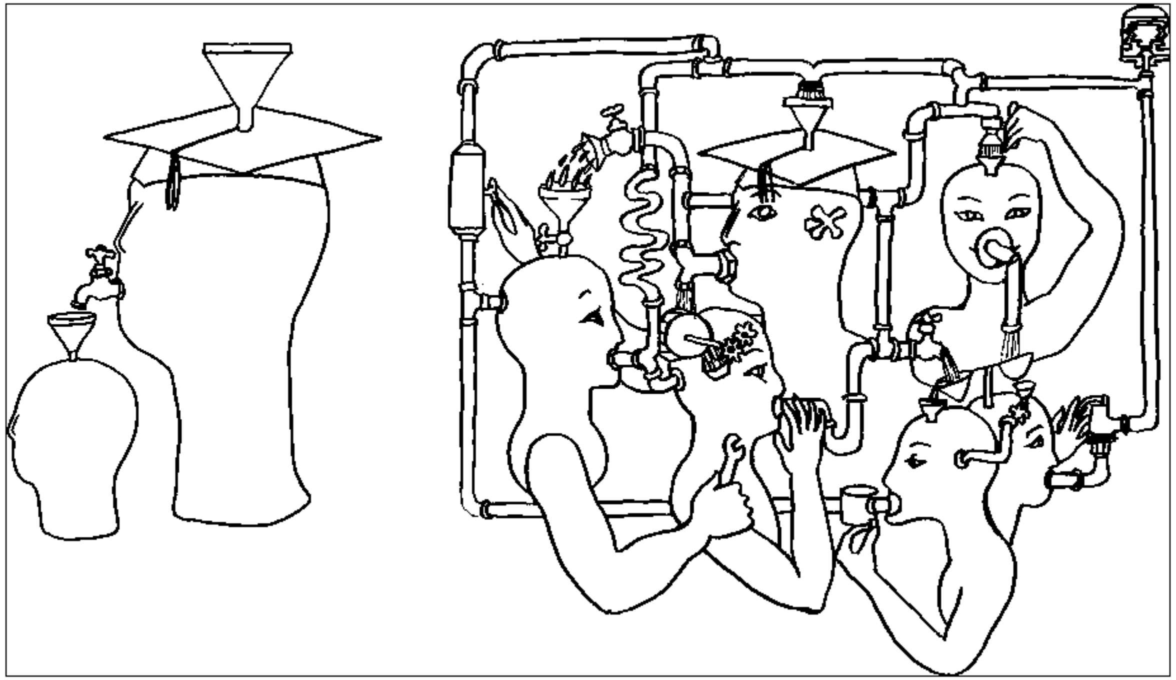


Part 6

Elements of Cooperative Learning

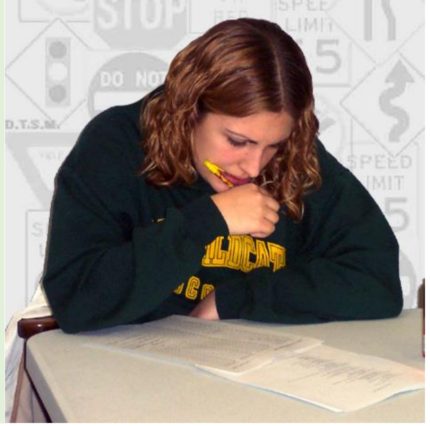
Elements of Cooperative Learning

Positive Interdependence: Team members must rely on each other to accomplish goals.

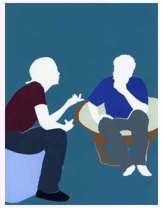
Group Processing: Teams periodically reflect on what they do well as a team and what they could improve.

Face-to-Face Interaction: Some or all work should be done by members working together.

Individual Accountability: Each team member is held accountable for doing their share of the work, as well as mastering all material.



Social Skills: Team members practice and receive instruction in listening, meetings, leadership, decision-making, conflict management, and communication.



Efficacy of Cooperative Learning

Learning Outcome (cooperative vs. individualistic)	Effect Size
Improved academic achievement	0.64
Improved quality of interpersonal interactions	0.60
Improved self-esteem	0.44
Improved perceptions of greater social support	0.70
Improved academic achievement	0.53
Improved quality of interpersonal interactions	0.55
Improved self-esteem	0.29
Improved perceptions of greater social support	0.51

Johnson, D., Johnson, R., & Smith, K. A. (1998). Active Learning: Cooperation in the College Classroom, 2nd ed., Edina, MN: Interaction Book Co.Johnson, D., Johnson, R., & Smith, K. A. (1998). Active Learning: Cooperation in the College Classroom, 2nd ed., Edina, MN: Interaction Book Co.

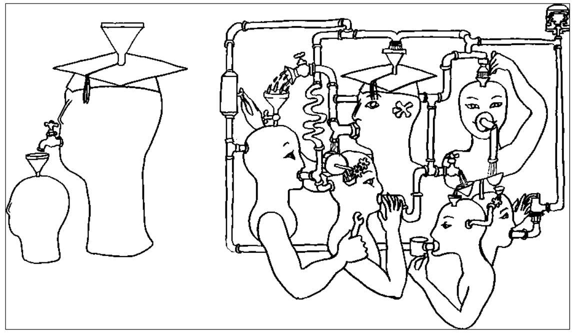
Johnson, D., Johnson, R., & Smith, K. A. (1998) Cooperative learning returns to college: What evidence is there that it works? *Change, 30*(4), 26–35. doi:10.1080/00091389809602629

Efficacy of Cooperative and/or Small Group Learning

Learning Outcome (small group vs. individual)	Effect Size
Improved academic achievement	0.51
Improved student attitudes	0.55
Improved retention in academic programs	0.46

Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research, 69*(1), 21-51. doi:10.3102/00346543069001021

Positive Interdependence

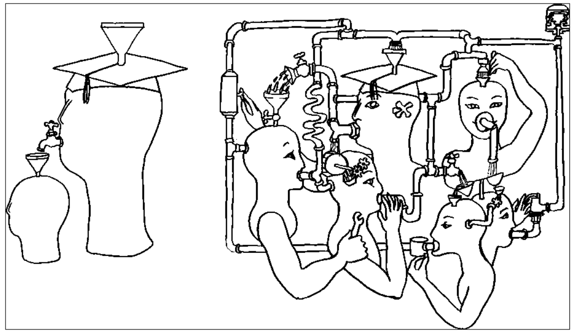


Team members must rely

on each other to

accomplish goals.

Positive Interdependence



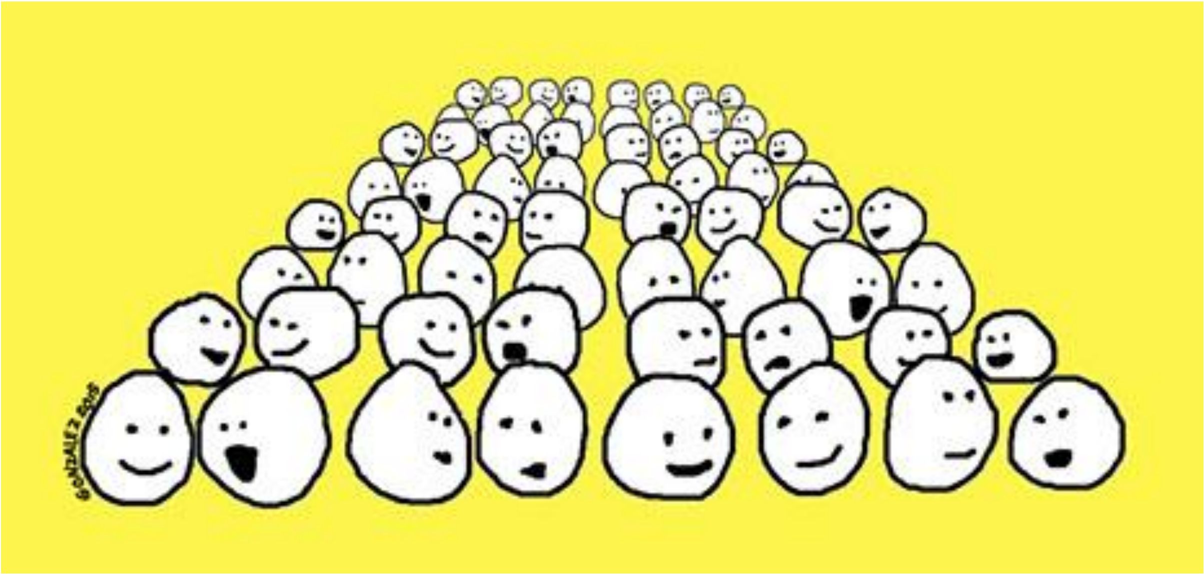
- Perhaps the biggest mistake faculty members make when assigning teams of students to work on an assignment is that the assignment does not require a team to do the assignment.
- Perhaps another mistake is not providing sufficient structure to support the students who are working in teams.

How might you promote positive interdependence in team assignments you make?

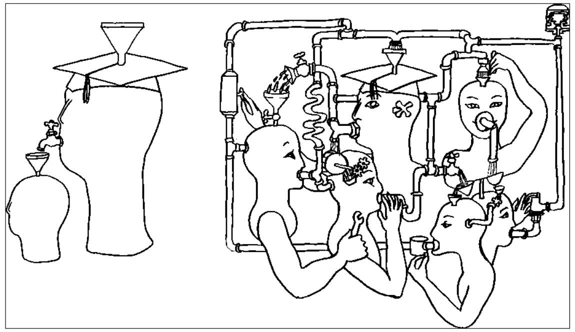
Please write down your responses individually

How might you promote positive interdependence in team assignments you make?

Please turn to your neighbor and exchange answers.

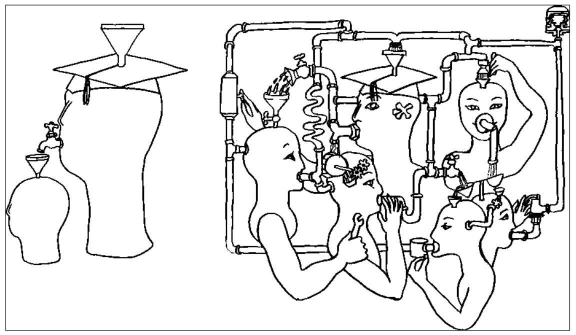


Positive Interdependence

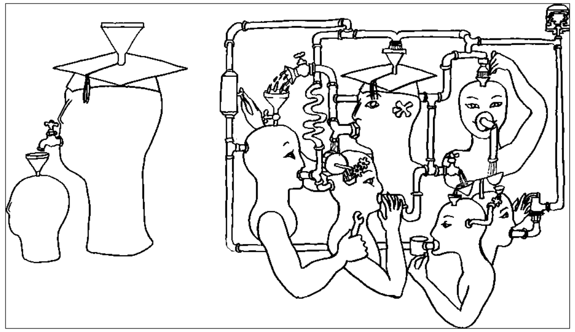


- Each member of the group should present part of the project
- Assign a problem that is not straightforward, it requires reading, research, etc.
- Each individual may earn different scores
- Problem has different components
- Each group makes a task sheet with responsibilities for each individual
- Assign clear tasks with clear accountability
- Each group has members with responsibility for different roles (RACI)
- Ask each group to look at the problem in a different way

Positive Interdependence



- Break problem into smaller parts and assign parts to individuals\
- Tighten the deadline
- Make the assignment demanding
- Real-world applications

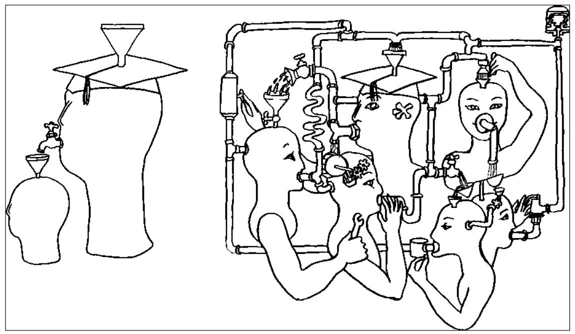


Positive Interdependence

- **Task Interdependence** – Give a team a common task
- **Role Interdependence** – Assign team members different roles and rotate
- **Reward Interdependence** – Offer bonus points if every member achieves a set requirement
- **Resource Interdependence** – Limit resources and develop complementary expertise

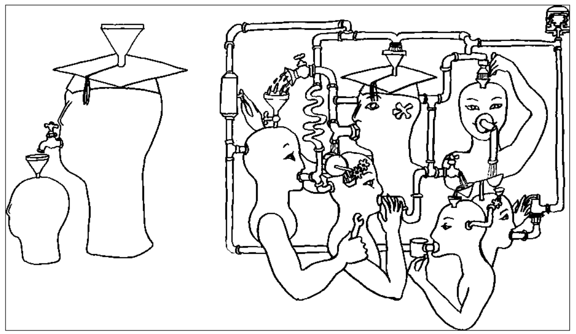
Positive Interdependence: https://en.wikipedia.org/wiki/Positive_interdependence

Individual Accountability



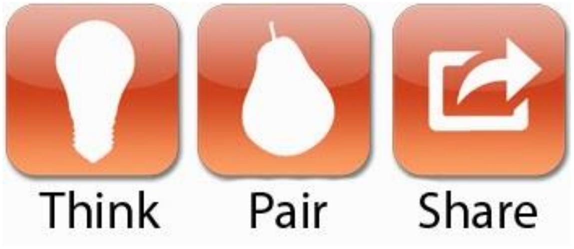
Each team member is held accountable for doing their share of the work, as well as mastering all material

Individual Accountability



- Perhaps the second biggest mistake faculty members make when assigning teams of students to work on an assignment is that the assignment does not require each team member to demonstrate their individual learning.

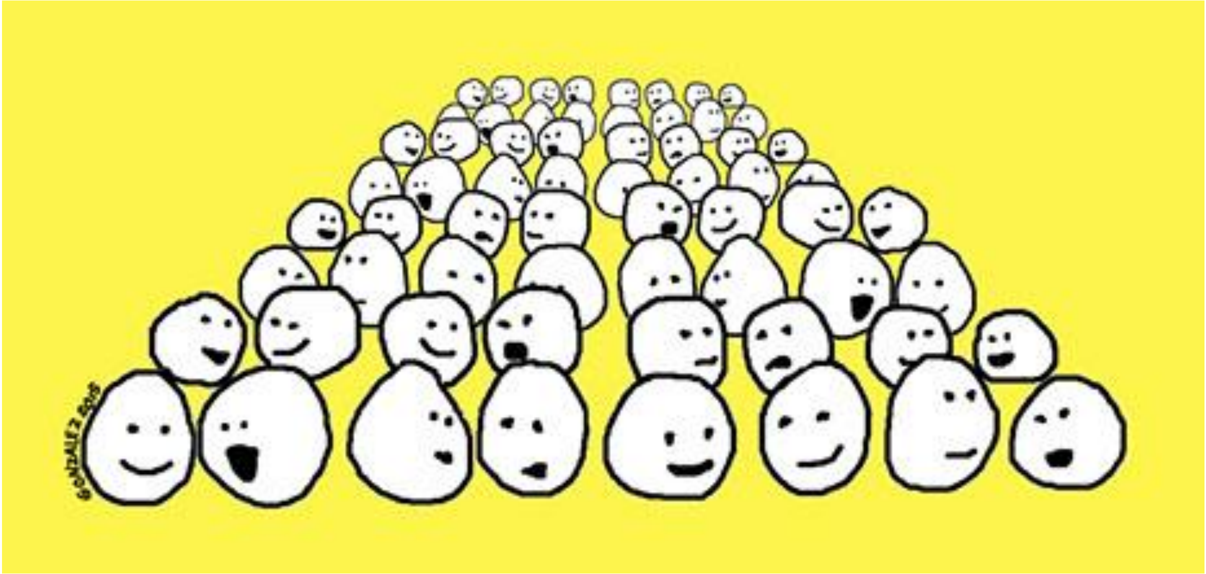
How might you promote individual accountability in team assignments you make?



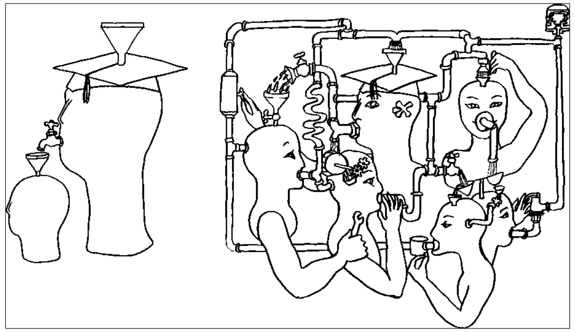
Please write down your responses individually

How might you promote individual accountability in team assignments you make?

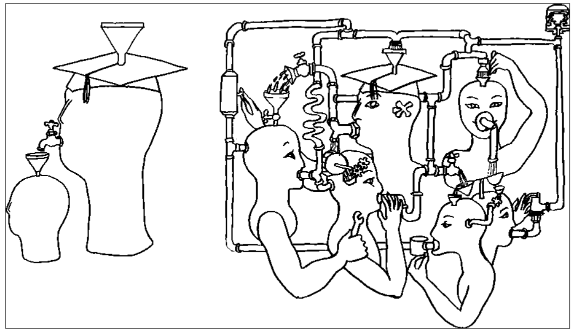
Please turn to your neighbor and exchange answers.



Individual Accountability



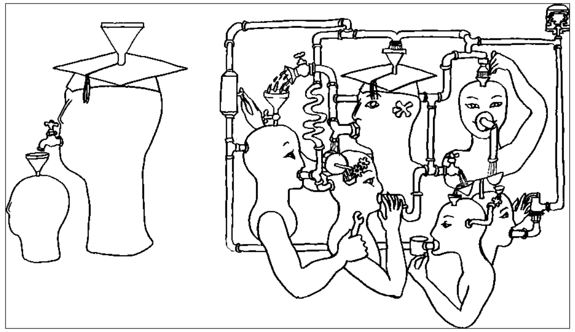
- In a presentation, the presenter for a slide or segment will be selected randomly by the thoughtful instructor
- Set assessment characteristics for each individual and allow other members of group to contribute to the assessment
- Give short individual quiz
- Ask a student in the group to explain to rest of the class
- Peer assessment
- Evaluated on RACI role



Individual Accountability

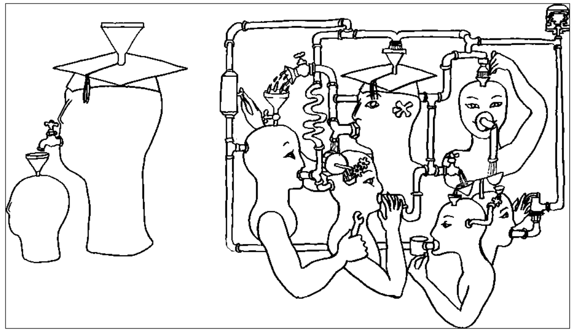
- Individual assessment
- Assign specific responsibilities to each individual
- Peer review
- Penalty for free rider

Individual Accountability



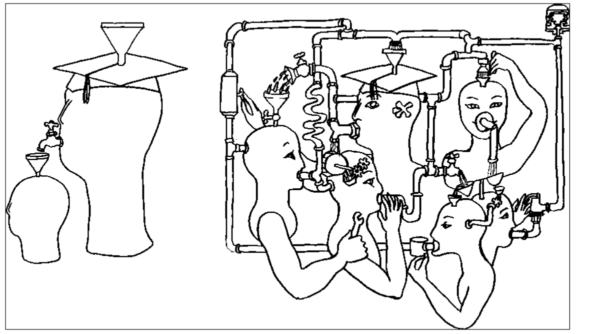
- Individual exams
- Random checking, e.g., choosing responsibility for parts of oral presentation randomly at the time of the oral presentation
- Ask one member at random to explain results/learning
- Small groups, cuts down slackers
- Ask members to apply group learning to individual task, e.g., individual report memos
- Everyone signs: “I participated, I agree, and I can explain the information”

Face-to-face Promotive Interaction



Team members must interact face-to-face from time-to-time.

Face-to-face Promotive Interaction



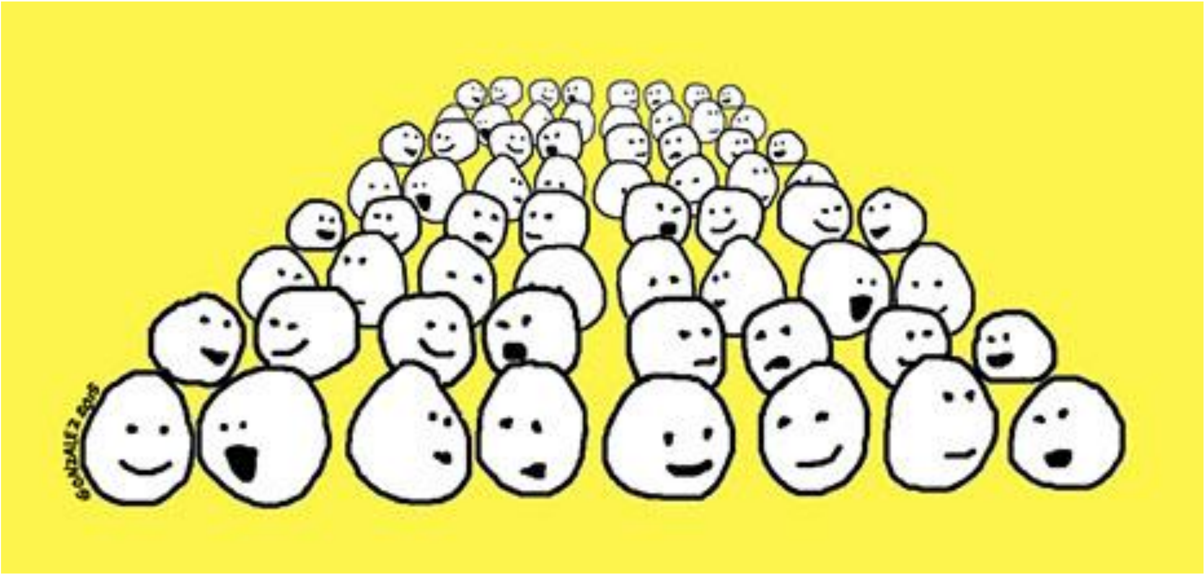
- Perhaps another mistake faculty members make when assigning teams of students to work on an assignment is that the assignment allows the team to divide-and-conquer without coordination, peer review, peer interaction, etc.

How might you promote face-to-face promotive interaction in team assignments you make?

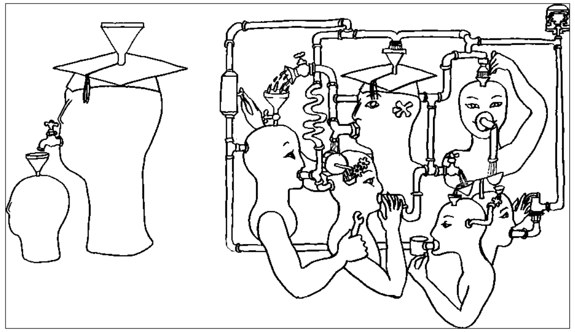
Please write down your responses individually

How might you promote face-to-face promotive interaction in team assignments you make?

Please turn to your neighbor and exchange answers.

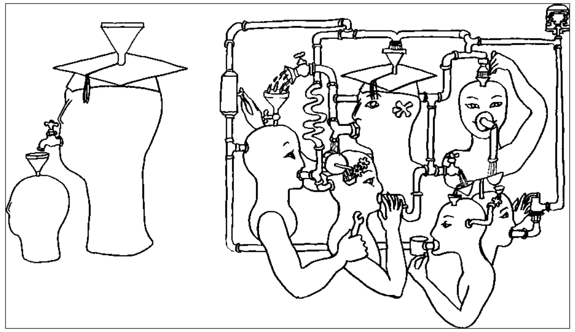


Face-to-face Promotive Interaction



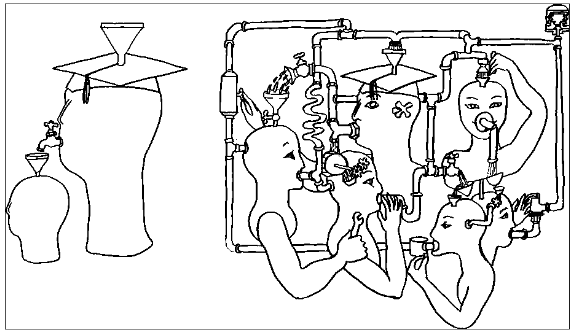
- Use schedule meeting at the beginning and require progress meetings
- Short meeting minutes from each student about her part
- Request action items from each meeting
- Ask each person to write what they will do next
- Each person reports her progress
- Midway report after meeting with individual reports
- Make a group video
- Google Classroom and Microsoft Teams – record meeting minutes and actions

Face-to-face Promotive Interaction



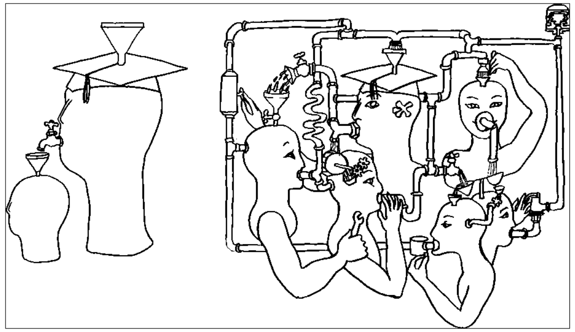
- Avoid assignments that can be parceled out, e.g., long papers, extended programming assignments
- Ask team to generate multiple good ideas and you pick one for further work
- Scratch-off questions (https://www.funfaculty.org/drupal/book/export/html/4189)
- Ask multiple choice questions and require one answer from team
- Form heterogeneous groups to promote diverse perspectives

Group Processing



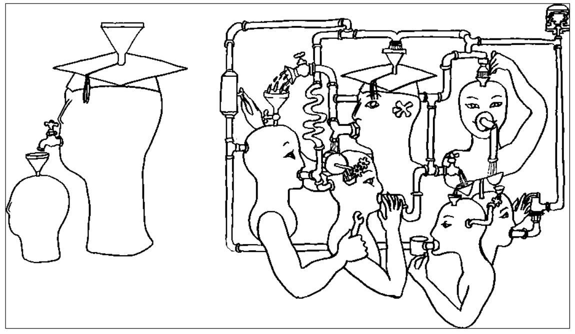
Teams, to improve their performance as a team, need to periodically reflect on what they do well as a team, what they could improve, and what they might need to do differently.

Group Processing



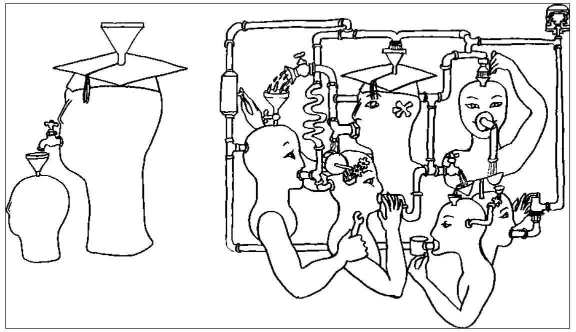
- Complete plus-delta at end of team assignment
- Ask teach team to develop and document a Code of Cooperation, aka, team constitution, team bylaws, etc.
- Ask for reflections on team process during an extended project – What is working? What are challenges to be addressed?
- Ask: How is team meeting Code of Cooperation

Social/Interpersonal Skills

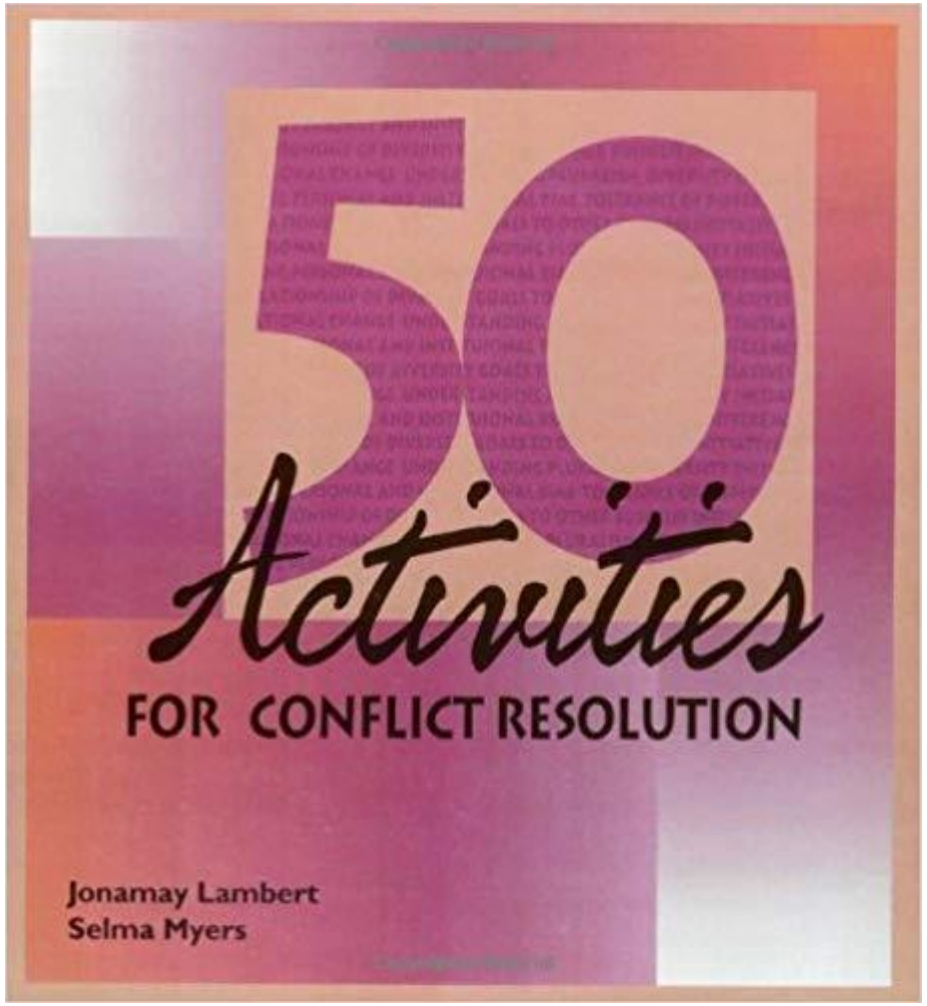


Team members practice and receive instruction in listening, meetings, leadership, decision-making, conflict management, and communication.

Social/Interpersonal Skills



- Use brief activities to develop listening skills
- Use brief activities to develop conflict management skills
- Use brief activities to develop interpersonal communication skills
- Provide guidance on effective meetings
- Use activities to develop skills in making decisions as a team



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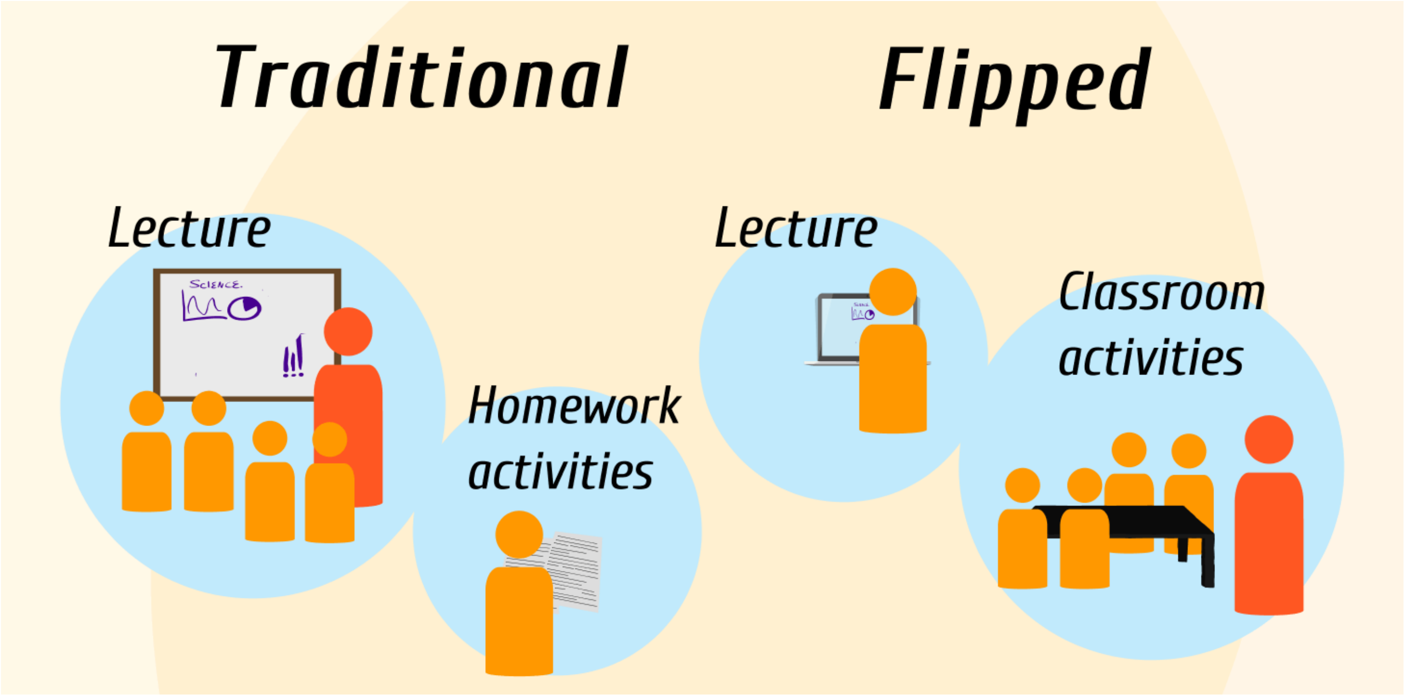


Part 7

Flipped / Blended / Hybrid Learning

What is the instructional strategy?

Traditional Approach

- Before first class on topic
  - Students do nothing
- During first class on topic
  - Teacher introduces topic
- After first class on topic
  - Students work on homework

Flipped Approach

- Before first class on topic
  - Students are introduced to the topic via video, readings… nothing
- During first class on topic
  - Students work [in teams] on exercises to practice learning outcomes
  - Feedback is provided
- After first class on topic
  - Students work on homework

Flipped Classroom / Hybrid Learning / Blended Learning

What is blended learning? Blended learning is a form of education that takes place both online and in a brick-and-mortar location.

Both of these modalities are integrated into a cohesive learning experience for the student.

In blended learning scenarios, “face time” between students and teachers is not replaced by online course delivery.

Rather, the online component of the learning experience usually consists of exercises or additional content that complement the in-class lesson.

Blended Learning, Hybrid Learning, The Flipped Classroom… What’s the Difference? https://www.panopto.com/blog/blended-learning-hybrid-learning-flipped-classroom-whats-difference/

Flipped Classroom / Hybrid Learning / Blended Learning

What is hybrid learning? Often, the term hybrid learning is used almost interchangeably with blended learning. However, there is a subtle distinction.

In hybrid learning, a significant portion of the course takes place online.

In contrast with blended learning, a hybrid learning scenario replaces much of the student-teacher "face time" in a brick-and-mortar location with online interaction.

Blended Learning, Hybrid Learning, The Flipped Classroom… What's the Difference? https://www.panopto.com/blog/blended-learning-hybrid-learning-flipped-classroom-whats-difference/

Flipped Classroom / Hybrid Learning / Blended Learning

What is a flipped classroom? The flipped classroom is another form of blended learning where:

- A student is first exposed to new material outside of class, usually in the form of an online presentation.
- When the student attends class in a brick-and-mortar setting, the class time is used to apply the material in the form of problem-solving and discussion.

Blended Learning, Hybrid Learning, The Flipped Classroom… What's the Difference? https://www.panopto.com/blog/blended-learning-hybrid-learning-flipped-classroom-whats-difference/

Flipped Classroom / Hybrid Learning / Blended Learning

For these instructions approaches, the instructor is asking:

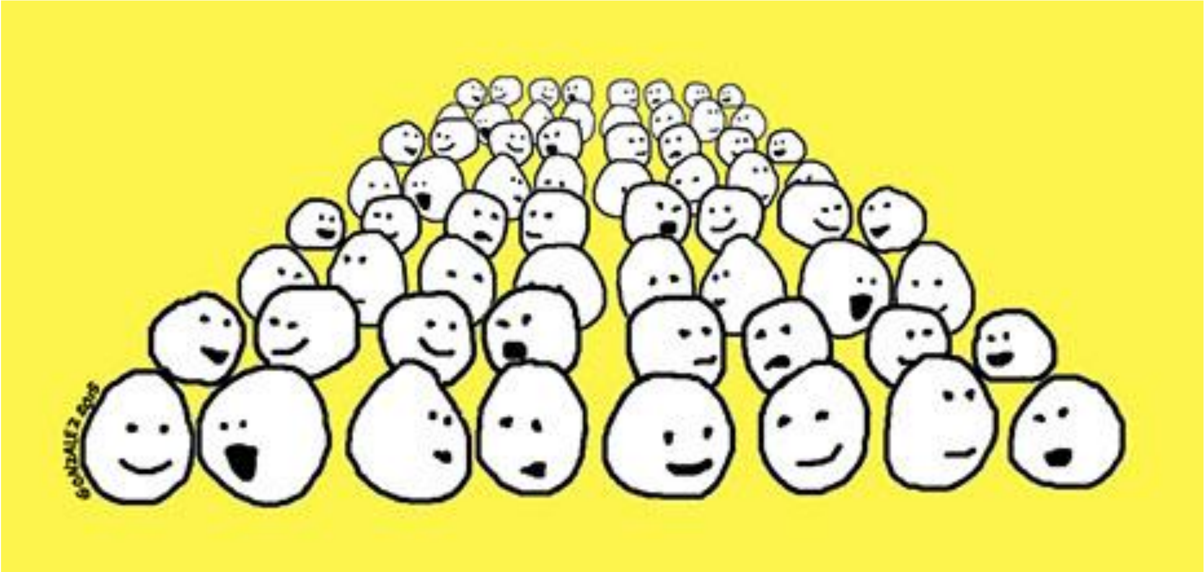
- What can students do outside the classroom working individually, e.g., online, to help attain the learning outcomes for the course?
- What can best be accomplished in the physical classroom where all the students and the teacher are physically co-located?

Describe how you might blend online and in-classroom instructional approaches?

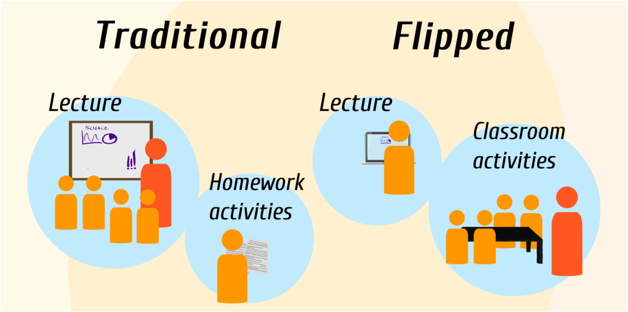
Please write down your responses individually

Describe how you might blend online and in-classroom instructional approaches?

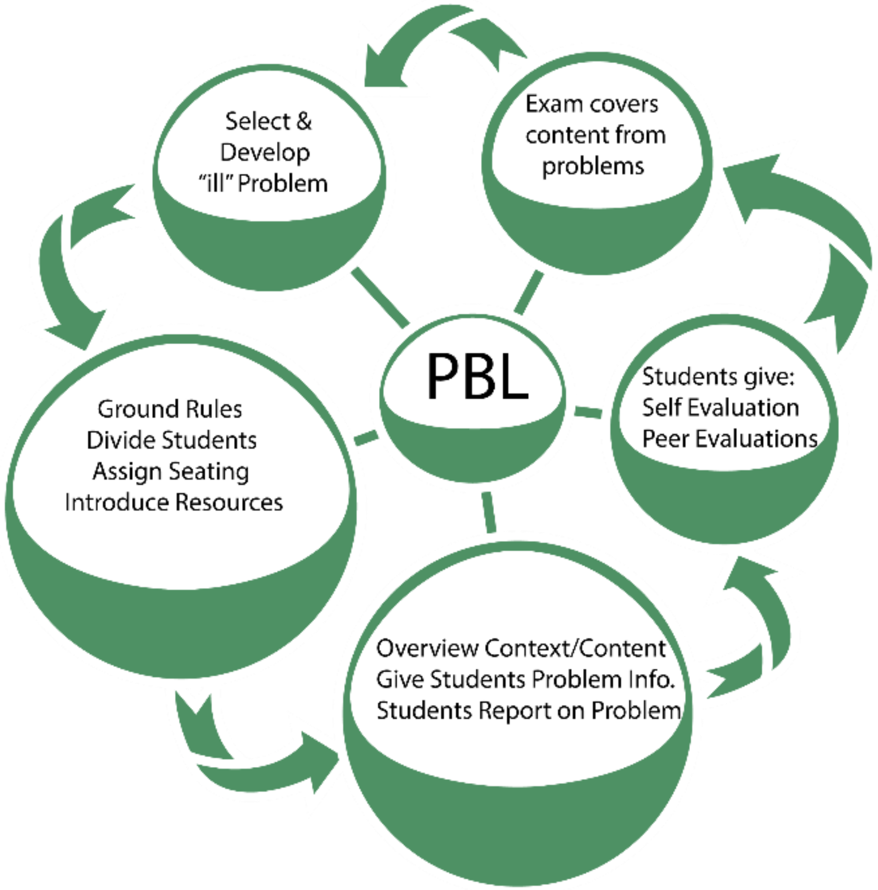
Please turn to your neighbor and exchange answers.



Blended / Hybrid / Flipped Instructional Approaches



- Please share your answers with the group



Part 8

Problem-based Learning

Problem-based Learning

Problem-based learning (PBL) is a student-centered approach in which students learn about a subject by working in groups to solve an open-ended problem. This problem is what drives the motivation and the learning.

Problem-based Learning: https://teaching.cornell.edu/teaching-resources/engaging-students/problem-based-learning

Problem-based Learning

Learning is initiated by a problem.

Problems are based on complex, real-world situations.

All information needed to solve problem is not given initially.

Students identify, find, and use appropriate resources.

Students work in permanent groups.

Learning is active, integrated, cumulative, and connected.

Serva, M., & Watson, G. (2011). What is Problem-Based Learning. Retrieved from http://www1.udel.edu/pbl/yzu/yzu-lecture-2008.pdf

Problem-based Learning

aka Project-based Learning

aka Inquiry-based Learning

aka Challenge-based Learning

aka Project-based Service Learning

aka ...

Problem-based Learning: https://teaching.cornell.edu/teaching-resources/engaging-students/problem-based-learning

Problem-based Learning (PBL)

Unfacilitated PBL	Guided/Facilitated PBL
Disaster!	See following slides

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59*(1), 14-19. https://dx.doi.org/10.1037/0003-066X.59.1.14

Process Oriented Guided Inquiry Learning (POGIL)

“[In] a typical POGIL classroom or laboratory, students work in small teams with the instructor acting as a facilitator. The student teams use specially designed activities that generally follow a learning cycle paradigm”

https://pogil.org/about-pogil/what-is-pogil

Problem-based Learning

Studies Supporting Efficacy with respect to Student Learning

Differences in Residency Directors' Perceptions of University of Missouri—Columbia School of Medicine Graduates on 17 Individual Characteristics Before and After Implementation of a Problem-Based Learning Curriculum

Characteristic	**p value**
General fund of knowledge	< 0.01
Physical diagnosis and history taking	< 0.01
Ability to manage expected number of patients	< 0.01
Medical judgment/ability to perform under pressure	< 0.01
Quality of written presentations	< 0.01
Quality of oral presentations	< 0.01

Hoffman, K., Hosokawa, M., Robert Blake, J., Headrick, L., & Johnson, G. (2006). Problem-based learning outcomes: Ten years of experience at the University of Missouri-Columbia School of Medicine. *Academic Medicine, 81*(7), 617-625. doi:10.1097/01.ACM.0000232411.97399.c6

Differences in Residency Directors' Perceptions of University of Missouri—Columbia School of Medicine Graduates on 17 Individual Characteristics Before and After Implementation of a Problem-Based Learning Curriculum

Characteristic	**p value**
Effectiveness with patients	< 0.05
Ability to teach medical students	< 0.01
Communication with others on health-care team	< 0.01
Level of maturity	< 0.01
Willingness to accept responsibility	< 0.01
Initiative	< 0.01

Hoffman, K., Hosokawa, M., Robert Blake, J., Headrick, L., & Johnson, G. (2006). Problem-based learning outcomes: Ten years of experience at the University of Missouri-Columbia School of Medicine. *Academic Medicine, 81*(7), 617-625. doi: 10.1097/01.ACM.0000232411.97399.c6

Differences in Residency Directors' Perceptions of University of Missouri—Columbia School of Medicine Graduates on 17 Individual Characteristics Before and After Implementation of a Problem-Based Learning Curriculum

Characteristic	**p value**
Willingness to help others	Not significant
Ability to accept criticism	< 0.01
Self-confidence	Not significant
Sensitivity to psychosocial needs of patients	Not significant
Projects qualities of a good physician	< 0.01

Hoffman, K., Hosokawa, M., Robert Blake, J., Headrick, L., & Johnson, G. (2006). Problem-based learning outcomes: Ten years of experience at the University of Missouri-Columbia School of Medicine. *Academic Medicine, 81*(7), 617-625. doi: 10.1097/01.ACM.0000232411.97399.c6

Results of Meta-analysis of Studies on Problem-based Learning (Main Effects)

Outcome	Number of Studies	Significant Positive Outcome	Significant Negative Outcome	Average Effect Size	
				Unweighted	Weighted (CI 95%)
Knowledge	18	7	15	-0.776	-0.223 (∓0.058)
Skills	17	14	0	+0.658	0.460 (∓0.058)

Dochy, F., Segers M., Van den Bossche, P., and Gijbels, D. (2003). Effects of Problem-Based Learning: A Meta-Analysis. *Learning and Instruction, 13*, 533–568. doi: 10.1016/S0959-4752(02)00025-7

Scope of Implementation as Moderating Variable

Outcome	Number of Studies	Significant Positive Outcome	Significant Negative Outcome	Average Effect Size	
				Unweighted	Weighted (CI 95%)
Knowledge					
Single Course	9	6	4	-0.578	-0.113 (∓0.071)
Curriculum	9	1	10	-0.974	-0.339 (∓0.099)
Skills					
Single Course	6	4	6	+0.636	0.187 (∓0.081)
Curriculum	10	9	0	+0.660	0.311 (∓0.085)

Dochy, F., Segers M., Van den Bossche, P., and Gijbels, D. (2003). Effects of Problem-Based Learning: A Meta-Analysis. *Learning and Instruction, 13*, 533–568. doi: 10.1016/S0959-4752(02)00025-7

Results of Meta-analysis of Studies on Problem-based Learning (Main Effects)

Outcome	Number of Studies	Significant Positive Outcome	Significant Negative Outcome	Average Effect Size	
				Unweighted	Weighted (CI 95%)
Concepts	21	3	5	-0.042	-0.068 (∓0.864)
Principles	15	17	1	+0.748	0.795 (∓0.782)
Application	13	6	0	+0.401	0.339 (∓0.662)

Gijbels, D., Dochy, F., Van den Bossche, P., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of Educational Research, 75*(1), 27-61. doi:10.3102/00346543075001027

Does Problem-Based Learning Work? A Meta-Analysis of Evaluative Research

Abstract: The purpose of this review is to synthesize all available evaluative research from 1970 through 1992 that compares problem-based learning (PBL) with more traditional methods of medical education. Five separate meta-analyses were performed on 35 studies representing 19 institutions. For 22 of the studies (representing 14 institutions), both effect-size and supplementary vote-count analyses could be performed; otherwise, only supplementary analyses were performed. PBL was found to be significantly superior with respect to students' program evaluations (i.e., students' attitudes and opinions about their programs)--dw (standardized differences between means, weighted by sample size) = +.55, CI.95 = +.40 to +.70 - and measures of students' clinical performance (dw = +.28, CI.95 = +.16 to +.40). PBL and traditional methods did not differ on miscellaneous tests of factual knowledge (dw = -.09, CI.95 = +.06 to -.24) and tests of clinical knowledge (dw = +.08, CI.95 = -.05 to +.21). Traditional students performed significantly better than their PBL counterparts on the National Board of Medical Examiners Part I examination--NBME I (dw = -.18, CI.95 = -.10 to -.26). However, the NBME I data displayed significant overall heterogeneity (Qt = 192.23, p < .001) and significant differences among programs (Qb = 59.09, p < .001), which casts doubt on the generality of the findings across programs. The comparative value of PBL is also supported by data on outcomes that have been studied less frequently, i.e., faculty attitudes, student mood, class attendance, academic process variables, and measures of humanism. In conclusion, the results generally support the superiority of the PBL approach over more traditional methods.

Vernon, D. T. A., and Blake, R. L. (1993). Does Problem-Based Learning Work? A Meta-Analysis of Evaluative Research. *Academic Medicine*, *68*(7), 550-563.
https://dx.doi.org/10.1097/00001888-199307000-00015

What's So Good About Problem-Based Learning?

Abstract: In a systematically designed and controlled experiment conducted in a naturalistic instructional setting, we examined adult students' learning of two concepts. Two intact classes taught by the same instructor were assigned to 1 of 2 conditions. In 1 class, instruction was problem based for 1 concept. For a second concept, lecture/discussion was the exclusive method. In the other class, matching of concept and method (problem based or lecture/discussion) was reversed. Two forms of assessment of learning occurred 6 and 12 weeks following instruction. At the initial assessment, the lecture/discussion group showed superior learning for 1 concept and the groups performed equivalently for the other concept. At the later assessment, however, the 2 groups showed equivalent ability to access each of the concepts, but each group showed superior explanation of the concept for which they had experienced problem-based learning. Results support the hypothesis of integration of new information with existing knowledge structures activated by the problem-based experience as the mechanism by which problem-based learning produces its benefits.

Capon, N., and Kuhn, D. (2004). What’s so good about problem-based learning? *Cognition and Instruction, 22*(1), 61–79.
https://dx.doi.org/10.1207/s1532690Xci2201_3

A Problem-based Learning Meta-analysis: Differences across Problem Types, Implementation Types, Disciplines, and Assessment Levels

Abstract: Problem based learning (PBL) in its most current form originated in Medical Education but has since been used in a variety of disciplines (Savery & Duffy, 1995) at a variety of educational levels (Savery, 2006). Although recent meta analyses have been conducted (Dochy, Segers, Van den Bossche, & Gijbels, 2003; Gijbels, Dochy, Van den Bossche, & Segers, 2005) that attempted to go beyond medical education, they found only one study in economics and were unable to explain large portions of the variance across results. This work builds upon their efforts as a meta-analysis that crosses disciplines as well as categorizes the types of problems used (Jonassen, 2000), the PBL approach employed (Barrows, 1986), and the level of assessment (Gijbels et al., 2005; Sugrue, 1993, 1995). Across 82 studies and 201 outcomes the findings favor PBL (dw = 0.13±0.025) with a lack of homogeneity (Q = 954.27) that warrants a closer examination of moderating factors.

Walker, A., & Leary, H. M. (2009). A problem based learning meta analysis: Differences across problem types, implementation types, disciplines, and assessment levels. *The Interdisciplinary Journal of Problem-based Learning, 3*(1), 12–43. https://dx.doi.org/10.7771/1541-5015.1061

When is PBL More Effective? A Meta-synthesis of Meta-analyses Comparing PBL to Conventional Classrooms

Abstract: Problem-based learning (PBL) has been utilized for over 40 years in a variety of different disciplines. Although extensively researched, there is heated debate about the effectiveness of PBL. Several meta-analyses have been conducted that provide a synthesis of the effects of PBL in comparison to traditional forms of instruction. This study used a qualitative meta-synthesis approach to compare and contrast the assumptions and findings of the meta-analytical research on the effectiveness of PBL. Findings indicated that PBL was superior when it comes to long-term retention, skill development and satisfaction of students and teachers, while traditional approaches were more effective for short-term retention as measured by standardized board exams. Implications are discussed.

Strobel, J., & Barneveld, A. v. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *The Interdisciplinary Journal of Problem-based Learning, 3*(1), 44–58. https://dx.doi.org/10.7771/1541-5015.1046

Efficacy of Challenge-based Learning

	All KBQ	Less Difficult KBQ	More Difficult KBQ
Percentage of KBQ in which CBI class scored significantly* higher than Control class	26%	19%	35%
Percentage of KBQ in which Control class scored significantly* higher than CBI class	8%	11%	4%
Percentage of KBQ in which there were no significant differences between CBI and Control classes	66%	70%	61%
Number of KBQ	50	27	23

KBQ - Knowledge-based Questions
CBI - Challenge-based Instruction
* - $p < 0.05$ by t-test

Roselli, R. J., and Brophy, S. P. (2006). Effectiveness of Challenge-Based Instruction in Biomechanics. *Journal of Engineering Education, 95*(4), 311–324. doi:10.1002/j.2168-9830.2006.tb00906.x

Efficacy of Challenge-based Learning

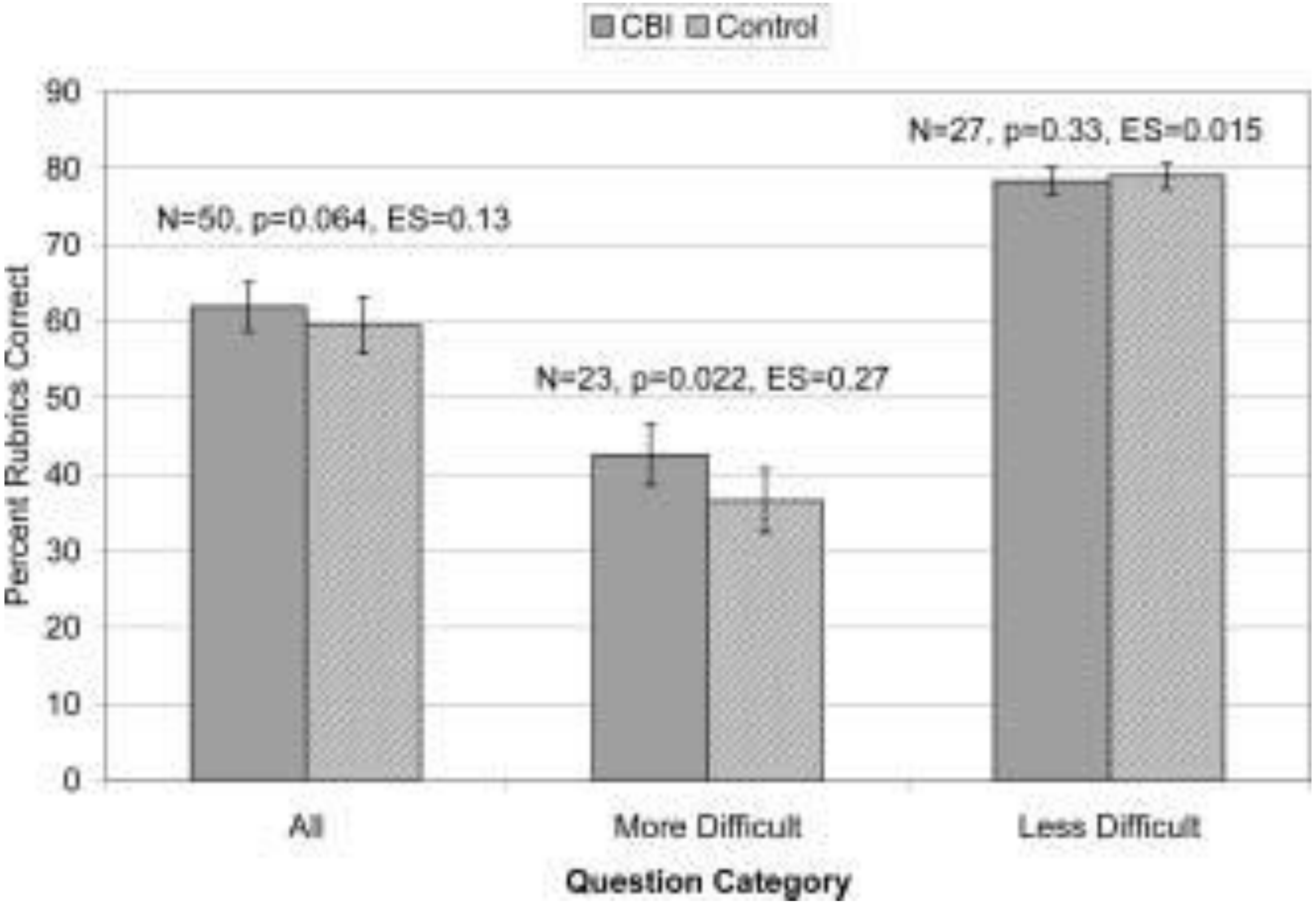


Figure 5. Comparison of average performance between CBI and Control classes on all knowledge based questions (left), more difficult KBQ (center) and less difficult KBQ (right). Error bars represent plus/minus one standard error of the mean. N is the number of questions in each group, ES is the average effect size, and p is the probability based on a single tail, paired t-test.

Roselli, R. J., and Brophy, S. P. (2006). Effectiveness of Challenge-Based Instruction in Biomechanics. J*ournal of Engineering Education, 95*(4), 311–324. doi:10.1002/j.2168-9830.2006.tb00906.x

Problem-based Learning: References

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- Capon, N., and Kuhn, D. (2004). What's so good about problem-based learning? *Cognition and Instruction, 22*(1), 61–79. doi:10.1207/s1532690Xci2201_3
- Dochy, F., Segers M., Van den Bossche, P., and Gijbels, D. (2003). Effects of Problem-Based Learning: A Meta-Analysis. *Learning and Instruction, 13*(5), 533–568. doi: 10.1016/S0959-4752(02)00025-7
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Project-based Learning

If you want to read a little more about project-based learning, a good starting point is the following paper: Mills, J. E., & Treagust, D. F. (2003). Engineering education—Is problem-based or project-based learning the answer. *Australasian Journal of Engineering Education, 3*(2), 2-16.

Project-based Learning

Project-based learning is an instructional approach that intends to achieve learning goals that are consistent with expectations for engineering graduates by employers and graduate programs.

Learning goals for project-based learning are somewhat different than traditional engineering science courses that emphasize lecture presentations; homework problems, often from end-of-chapter textbook problems; and exams that emphasize problems somewhat similar to homework problems.

In courses using project-based learning a faculty member begins a unit in the course by presenting a project to students before presenting content (e.g., definitions, concepts, examples, etc.). The project is the focus of the unit and student teams will address the project by presenting one of many reasonable possibilities, with some possibilities being better (evaluated by a set of criteria that are part of the project assignment). A faculty member chooses the project so that students will apply and learn much of the unit content when addressing the project goals. Project-based learning is a close relative to several other instructional approaches including problem-based learning, inquiry-based learning, and guided inquiry learning. Studies supporting the efficacy of project-based learning and its relatives are numerous and compelling.

Problem-based Learning

Effective problem-based learning instruction is based on three elements:

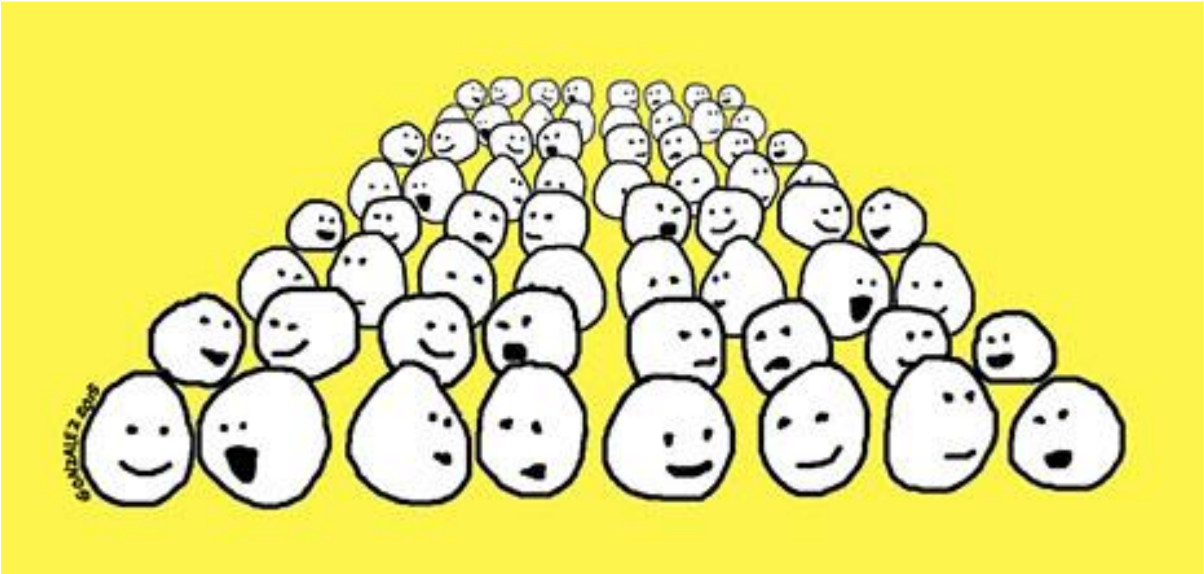
- Selecting problems/questions/projects/challenges/etc.
- Supporting students working in teams
- Facilitating student teams as they work through their hiccups.

Describe how you might get started on incorporating problem-based learning in your courses.

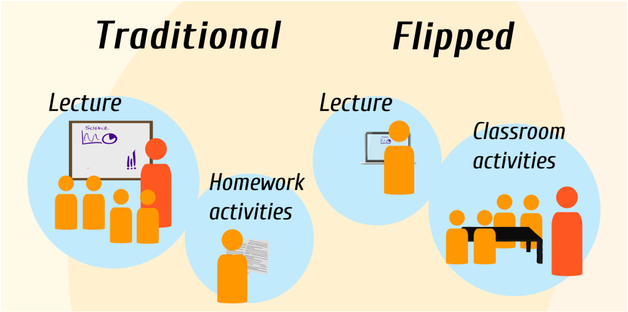
Please write down your responses individually

Describe how you might get started on incorporating problem-based learning in your courses.

Please turn to your neighbor and exchange answers.



Problem-based Learning Approaches



- Please share your answers with the group

Part 9

Using Student Teams Effectively

Faculty Questions about Student Teams

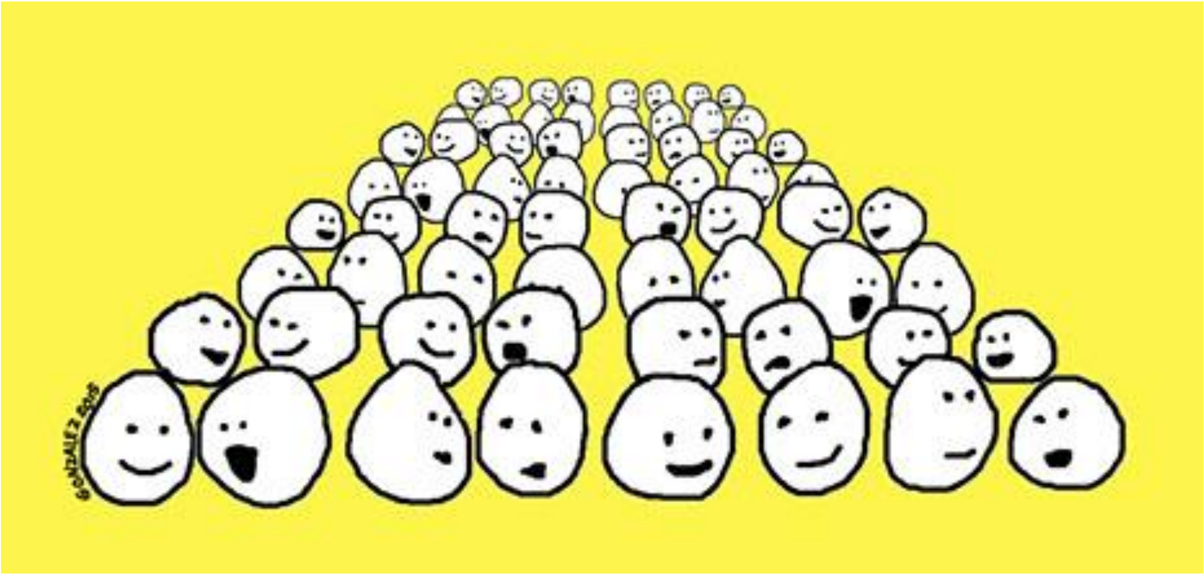
- How do I form teams?
- How do I get teams off to a good start?
- How do I facilitate dysfunctional teams?
- How do I give individual grades for team projects? (Individual Accountability)
- How do I monitor team progress?
- How do I help students develop team skills, e.g., meetings, listening, conflict resolution, interpersonal communication, decision making?

Describe how you would explain research-based instructional strategies to your colleagues?

Please write down your questions individually

Describe how you would explain research-based instructional strategies to your colleagues?

Please turn to your neighbor and exchange answers.



Describe how you would explain research-based instructional strategies to your faculty members

- Please share your answers with the group

Minute Paper

- Write brief answers to the following questions:
  - What is most valuable or helpful about research-based instructional strategies?
  - What is the “muddiest or most confusing point” about research-based instructional strategies?