

# Implementing Collaborative Learning through POGIL



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The University of Chicago

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# Context and Motivation

## History of IBL at UChicago

- One section of Honors Calculus (Math majors, placement by invitation only)
- Collaborative Learning started in Chemistry → expanded to other departments

## Target Course: Elementary Functions and Calculus (Math 130s)

- Students with weaker or nonexistent Calculus background
  - Mostly non-STEM majors
  - Approx 250 students/quarter
- Lectures (13 sections) --- mainly first-time Graduate Student Lecturers, coordinated by an IP
- Mandatory “tutorials” (2 per week) --- 26 undergraduate TAs
- Converted to Mastery-Based Grading in 2024-25
  - Exams and homework mostly assess lower-level Bloom’s skills

## Primary Goals

- Consistency in active learning and group work across sections
- Higher-level Bloom’s skills ← relaxed time constraints

## Solution

- Adapt POGIL → scalable model.
- Make tutorials collaborative and inquiry-based

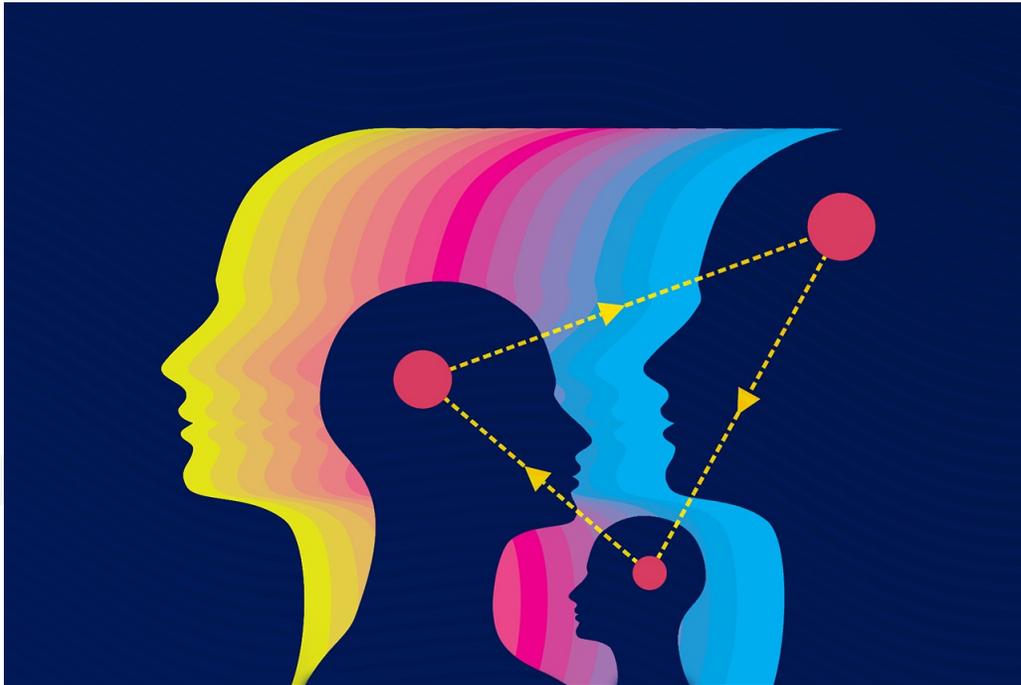
# Collaborative Learning





# Collective Intelligence

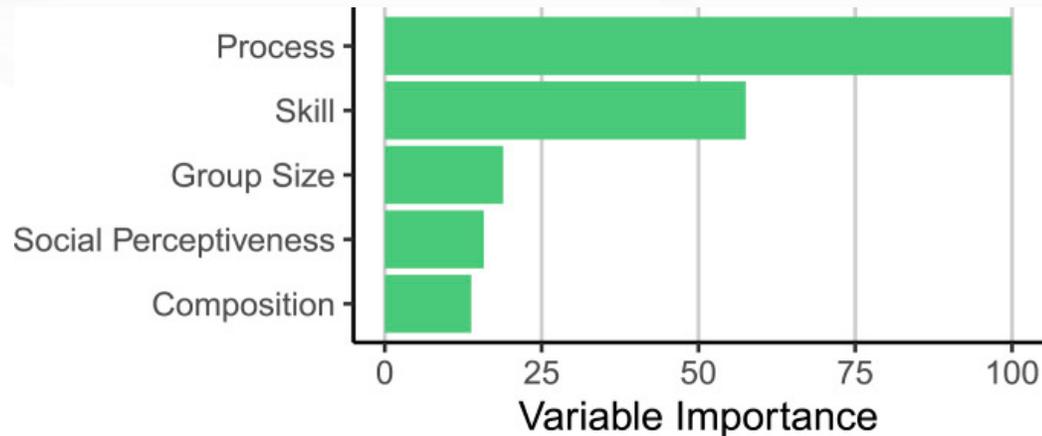
Riedl C, Kim YJ, Gupta P, Malone TW, Woolley AW. **Quantifying collective intelligence in human groups.** *Proc Natl Acad Sci U S A.* 2021 May 25;118(21):e2005737118. doi: 10.1073/pnas.2005737118.



- The general ability of the group to perform a wide variety of tasks
- Inference drawn from the correlation between group performance on tasks
- What are good predictors (high correlation) of CI?
- Meta-analysis from 22 studies, including 5279 individuals in 1356 groups



# What is the relative contribution to CI?



Variable importance is computed as the decrease in accuracy in prediction when a given variable is excluded from the model and expressed relative to the maximum.

- Individual Skill (mean and maximum)
- Social Perceptiveness (how well one can put themselves into the mind of another, equitable turn-taking)
- Collaboration Process (Skill congruence, Strategy, and Effort)
- Group Composition (gender balance and age diversity)
- Group Size



# Challenges to Successful Collaboration



**Off-Task Students**



100% effort



93% effort each



85% effort each

**Social Loafing**



**Unequal, Negative, or Low-quality Interaction**



**Diverse Skill Levels**

\*created using ChatGPT



# Five Vital Elements for Productive Cooperation (Johnson & Johnson, 1987; Johnson et al., 1998)

## Positive Interdependence

- Each student should **perceive** that they are linked with others in such a way that the student cannot succeed unless others do.

## Individual Accountability

- Learn together with the goal of subsequently performing better as individuals.
- Each student must **earn** their grades. Individual efforts must be measurable.

## Positive/Promotive Interactions

- Forge meaningful, face-to-face interactions (two to four members), students promote each other's success through helping, supporting, encouraging, and praising one another's efforts.

## Social skills

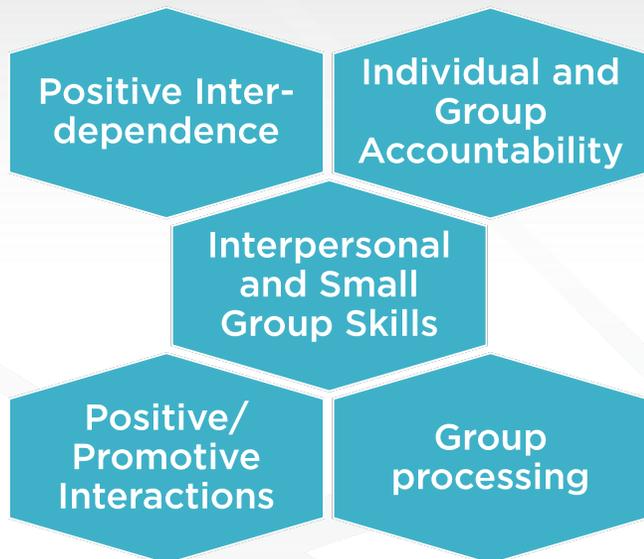
- Interpersonal skills needed to work effectively with others (leadership, trust-building, conflict management, etc.) are learned behaviors - need to be taught alongside academic skills.

## Group processing

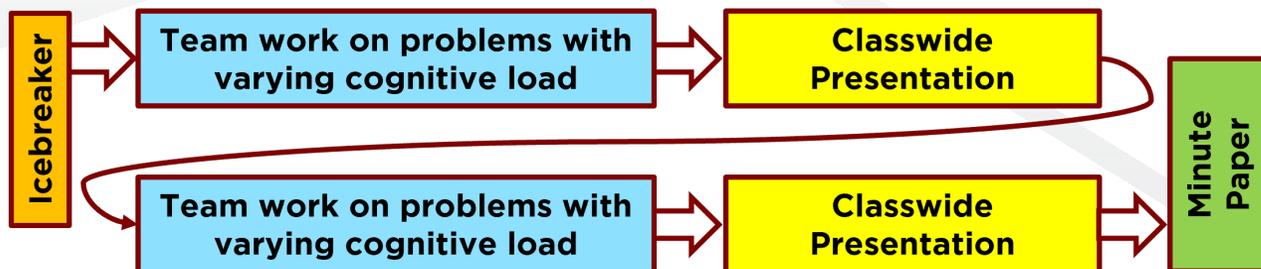
- Metacognition exercises - Take time to analyze the group's processes and identify possible improvements to become more efficient, more effective at working together.



# Structure of Collaborative Learning



## Structure of CL Tutorial



### Manager

- Ensure that the team stays on task and is focused.
- **Aims for** equitable turn-taking.

### Recorder

- Keeps a record of who plays what role in the team.
- Documents critical team insights for future reference.

### Spokesperson

- Presents the team's ideas to the rest of the class.
- Relays the success/challenges to the UTA
- **Must rely on the recorder's notes.**

### Strategy Analyst

- Observes team dynamics and guides the consensus-building process.
- **Initiates** a discussion of bolded prompts and records the reasoning behind decisions.

# Process Oriented

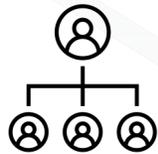
# Guided Inquiry Learning



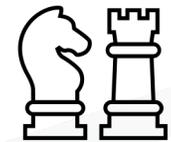
Teamwork



Critical Thinking



Management



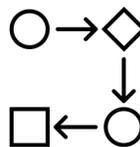
Problem Solving



Self+Peer Assessment



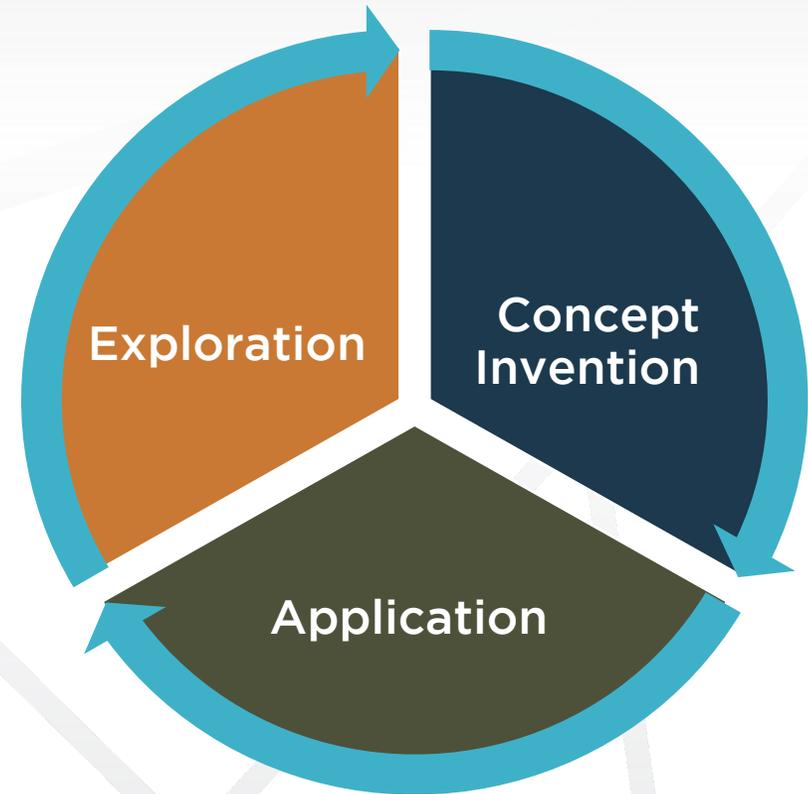
Communication



Information Processing



Metacognition





# Comparison of collaborative learning vs. group work

All collaborative learning is done in a group, but not all group work is inherently collaborative! (Scheuermann, 2018)

## COLLABORATIVE LEARNING

- Group effort required
- Learners accountable to each other
- Social skills are improved
- Helping and sharing is expected
- Emphasis on process and product

## “TRADITIONAL” GROUP WORK

- “Divide and Conquer” mentality
- More free-riders
- Minimal interaction required
- Helping and sharing is minimal
- Emphasis on product only

# Training Program





# Training Program for UTAs

## Pedagogy Training - 50 minutes

- Practice strategies for motivating students, managing group dynamics, and facilitating without lecturing
- LMS Course with reading and journaling assignment

## Lead a tutorial - twice a week

- Time management sheet
- Peer observation report
- Complete a pedagogy task and submit a reflection

## Content Analysis Training - 120 minutes

- Learning Goals ← Bloom's and Cognitive Demand
- Prior knowledge ← probing questions
- Possible misconceptions ← leading questions
- metacognitive question
  - slow down teams
  - confirm main takeaway



# The Five Practices (Smith & Stein)

- **Step 0. Set Goals and Select Tasks**
- **Step 1. Anticipate:** Predict how students might solve the task.
- **Step 2. Monitor:** Observe student work and discussion as it happens.
- **Step 3. Select:** Choose which student solutions/ideas to highlight.
- **Step 4. Sequence:** Order the chosen solutions in a purposeful progression.
- **Step 5. Connect:** Ask questions that link student ideas to mathematics



# Pedagogy Training Topics by Quarter

## Autumn: Collaborative Facilitation Strategies

- Utilizing Roles to balance contribution, manage time, and handle disruptive behavior
- Effective Communication
- Evidence-Based Observation
- Questioning Strategies
- Operant Conditioning
- Establishing Authority

## Winter: Science of Learning

- Cognitive Demand Framework
- SMART Goals
- Time Management
- Perry's Scheme
- Welcoming and equitable participation
- Process Skills
- Leveraging Feedback

## Spring: Knowledge Creation

- Backward Design
- Integrating Styles and Modes of Learning
- Understanding Student Thinking
- Conceptual AND/OR Procedural Knowledge
- Creating a Handbook for the future

# Task Design





# Designing Tutorial Problem Sets: Vision vs. Labor

## Philosophy

- ❑ promote positive interdependence and promotive interaction
- ❑ scaffolding conceptual tasks
- ❑ discovery-based learning
- ❑ encourage exploration, risk-taking, and productive struggle

## Challenges

- ❑ varying task types
- ❑ estimating cognitive load and student perception
- ❑ framing authentic contexts so students see why a problem matters
- ❑ writing metacognitive follow-ups that go deeper than additional applications.



# The 3-Step Loop

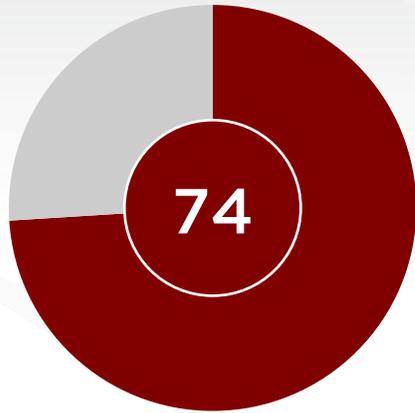
Step	Design intent	Prompt stems (pick 1-2)
1. Explore (POGIL)	Curiosity (EM). Activate prior knowledge: sense-making before method. Create a need for a technique.	Predict/estimate/Sketch first. What do you notice? What changes if we tweak ___? What would convince you?
2. Procedural work → Concept invention (POGIL)	Connections (EM). Procedures as a lens to reveal structure. Make students link representations/cases/methods.	Do it, then explain why each step is valid. Do it two ways; reconcile. Compare two cases; what stays invariant? Which method is better here, and why?
3. Apply (POGIL)	Creating Value (EM). Conceptual generalization: interpret, decide, classify, transfer. Move beyond the original instance.  Higher-level Bloom's.	Use the result to decide/recommend. Interpret in context (units/meaning). Classify: what problems are the same type? Generalize: when does this fail?

# Results

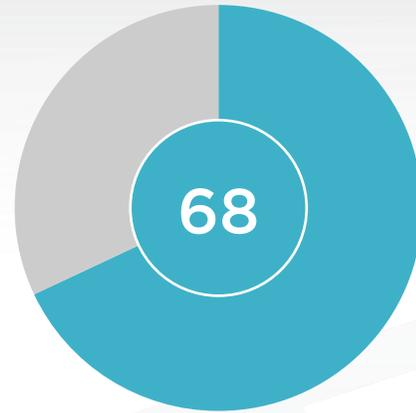




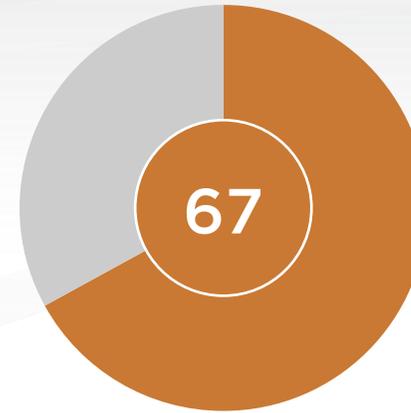
# Student Survey and Reflection



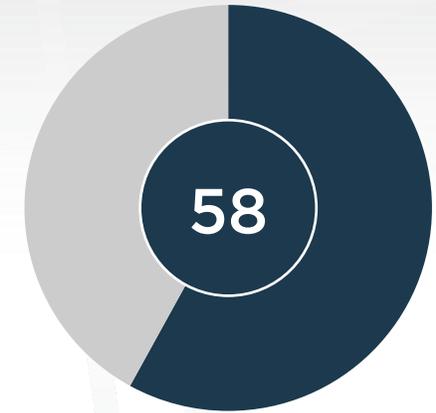
**Enhanced  
Teamwork and  
Accountability**



**Improved  
Critical Thinking  
and Problem-  
Solving Ability**



**Established  
Community and  
Belonging**



**Listening to  
Peers majorly  
contributed to  
learning**

- 47% stated the tutorials 'Enhanced' or 'Significantly enhanced' their learning (38% neutral, 15% negative)
- 'Minute Paper' was rated as one of the least effective components for learning



# Revisions and Future Goals

## Redesign 'Minute Paper'

- around half online check-ins via Canvas. For the other half, provide exact question instead of having the tutors come up with ideas.

## Stronger messaging

- not designed to be practice for their exam or homework, and assess a different skill set.

## Balance difficulty level

- Boost student confidence
- Replace with procedural questions before exams

## Enforce Role accountability

- Concrete deliverables for each individual

# Thank you for listening!

## Questions?

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