Structuring Interactions for Large-Scale Synchronous Peer Learning

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Motivation

- In physical classrooms, structured student interaction in small groups (a form of peer learning) promotes learning.
- In large online classes like MOOCs, there is risk of isolation.
- **Goal**: Design and evaluate a software system to bring peer learning to online classes.
Background: Peer learning: core ideas

- Students learn better by explaining to others (Johnson 1991)
- Extended group work should be structured (Millis 2012)
- Must promote both:
  - Positive interdependence: reward depends on success of group
  - Individual accountability: reward depends on doing your part
- Group makeup
  - Best if heterogeneous
  - Groups can change frequently
- Benefits supported by extensive research literature
Background: Interaction among students in MOOCs

- Formal long-term project groups: NovoEd (effective but requires fundamentally restructuring course)
- Discussion forums: essential, but low participation (Mak et al 2010)
- Informal groups: social media, local meetups
- Peer grading: asynchronous, anonymous evaluation of other students (Kulkarni et al, TOCHI 2014)
- Synchronous group discussions (Kulkarni et al, L@S 2015)
Participation can be higher with smaller groups (Voelpel et al 2008)
Participants

Wait Page

Next task in 5min

Next task in 5min

Next task in 5min

Initial Answer (2 min)


Group Discussion (5min)

Worker 1: I think the right answer is A, because...

Worker 2: But have you considered...

Final Answer (20 sec)


Group A, Question 1

Group B
Experimental questions

- Is discussing questions in groups helpful in this setting?
  - Varying: Some participants placed in groups, others work alone
  - Measuring: % correct final responses
- Will discussion be substantive (in-depth, on-topic)?
  - Measuring: manual coding of chat transcripts
- Positive interdependence: should participants receive a reward if everyone in their group gives correct answer?
  - Varying: Some groups are offered such a bonus, others are not
  - Measuring: % changed answers going from incorrect → correct
Example question (GMAT critical reasoning practice question)

With the decline of predators, such as wolves and coyotes, that used to keep the deer population within certain limits, deer have increased in numbers until they cannot feed themselves in the forest alone but must forage on open rangeland in competition with cattle. Thus, in areas where forest borders on rangeland, deer hunting is an essential activity.

This argument would be most seriously weakened if it could be shown that

A. deer hunters are not concerned about the prosperity of ranchers
B. wolves and coyotes do not prey upon deer only
C. deer and cattle do not eat the same plants
D. deer hunting is popular even in areas where the forest does not border rangeland
E. the deer population may someday be hunted out of existence
Participants

- Paid workers on Mechanical Turk take on role of students
- Allows rapid iteration on design
**Question**

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Choose one of A to E. Please scroll down if your screen does not display all choices.

**Possible Answers**

- **A**
  deer hunters are not concerned about the prosperity of ranchers
- **B**
  wolves and coyotes do not prey upon deer only
- **C**
  **✓** deer and cattle do not eat the same plants
- **D**
  deer hunting is popular even in areas where the forest does not border rangeland
- **E**
  the deer population may someday be hunted out of existence

**Discussion**

Discuss this question until the timer runs out. You may change your answer choice during the discussion.

**Student List**

- **Student 1**: I don't think the popularity of deer hunting is the issue.
- **Student 3**: Right, it's whether it's essential. If the deer and cattle don't eat the same plants, then deer hunting isn't essential to preserve the rangeland for the cattle.
- **Student 1**: That's how I see it.
- **Me**: Actually, I did not understand the question until now. Whoops.
- **Me**: I actually do believe it's C.
- **Student 3**: Awesome!
- **Me**: That was easy!
- **Student 3**: We all agree so let's hope for the bonus :)

**Timer**

03:10
Group formation

- Tasks begin at fixed times (e.g. every 5 minutes)
  - Can adjust to suit arrival rate
- When task begins, all waiting workers are placed in groups of 3 arbitrarily
  - Group remains same throughout task
Results: Discussion is helpful

- Higher % of correct final responses for workers in groups (Fisher’s test, p < 0.01)
Results: Discussion is substantive

- Rating scale:
  1. No relevant discussion
  2. Stated own answer
  3. Justified own answer
  4. Debated answer

- Most discussions were substantive (3 or 4)

- Inter-rater reliability: Spearman’s $\rho = 0.65$
Results: Bonus incentive is helpful

- About same % of workers changed answers in each condition (30% vs 33%)
- But a larger % of those changes were from incorrect to correct in the condition with the bonus incentive
  - 22% vs 11% (significant, Fisher's test, p < 0.03)
Motivation: so far, participants had to solve a new type of problem without any instruction

Question: If we introduce minimal instruction for this type of critical reasoning problem, how will it affect outcomes?

Vary: Some groups receive instruction, some don’t

Measure: % correct final answer
Teach workers a method for doing the problem
  1. Identify hidden assumptions in the provided argument
  2. Choose response that depends on those invalid assumptions

Step workers through the method as a group

Mini-lesson: 212 words

In this task you’ll learn a critical reasoning skill commonly calling identifying hidden assumptions. Read the following carefully.

[...]

Experiment 2: Mini-lesson
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Students individually write down unstated assumptions:

**Student 1**: deer eat the same food as cattle

**Student 2**: Deer are in competition with cattle for food and the only solution is to kill the deer. The assumption being there is a decline of predators, disregarding the biggest predators of all, humans.

**Student 3**: The assumption is that there are too many deer, and they do not have enough food in the forest. They have to feed on the ranges.

Discussion of assumptions:

**Student 1**: hi do we know that deer eat the same food as cattle

**Student 2**: It is assumed they would graze on grass

**Student 2**: But I don’t believe there is a shortage of predators as long as we are around

**Student 3**: It is assumed that they eat grass just like the cattle

**Student 2**: Jinx

**Student 1**: it is also assumed wolves and cyotes are the only predators

**Student 2**: We are master justifiers for our actions. M

**Student 3**: That is true

**Student 2**: Animal populations are not like people the breeding stops when there is nothing to eat
Experiment 2: Flows
Results: Mini-lesson helps

- Solo workers who viewed mini-lesson 7 to 17 times more likely to give correct response on first try
  - 11% correct → 58% correct
- Unsurprising (instruction improves performance)
- Acts as baseline (improvement from mini-lesson vs. from discussion)
Results: Discussion not shown to produce more correct responses

- Workers who participated in groups and viewed the mini-lesson got about the same percentage of answers correct as solo workers who just viewed the mini-lesson
  - 59.1% vs 58.6% correct on first question
  - 54% vs 56% correct on second question
Results: Revised answers improved

- In the longest flow, workers discussed their answers and then revised them, producing improvement
  - 61% correct before discussion → 74% after (Fisher’s, p < 0.002)
  - 1.2 to 2.6 times more likely to be correct after discussion
Results: Subjective impressions

- Most workers rated as enjoyable, and left positive feedback
- Similar results when deployed in real online course (53% rated enjoyable)
Pilot with real students

- Deployed in intro engineering course at University of Queensland with online component and >1000 students
- Used as part of weekly mandatory summative assessment
- High-quality discussions, and 53% rated task as enjoyable
- Compared to global MOOC: students are collocated and more committed to the course, making high participation easier to achieve
Discussion: Applicability to MOOCs

- Will the same approach work in real MOOCs?
- Turk workers and MOOC students have:
  - Similar levels of geographic dispersal and isolation
  - Comparable demographics (e.g. about 50-70% have Bachelor’s degrees)
  - Different motivations and community sizes
- Small pilots in MOOCs (~20 people)
  - Limited participation, but positive reception from participants
Discussion: Group formation

- Data shows groups with at least one correct student much more likely to reach correct answer.
- Suggests: dynamically base groups on initial answers.
Discussion: Implications for Crowd Work

- Discussion can improve results for tasks that involve problem solving and is more engaging for workers
  - Supports previous crowdwork findings (Zhu et al, CSCW 2014)
- Mini-lessons: brief training during task may improve results and enable new tasks
- Other ideas for improving crowd work may be inspired by learning research
Conclusions

- Peer learning can be done in online courses, can be integrated with instructional material, and is promising
- Students enjoy real-time group activities
- Encouraging positive interdependence is helpful
- The online setting offers new opportunities for structuring group activities
- Questions?