Group Cognition in Online Collaborative Math Problem Solving

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Promoting Collaborative Learning

- How can we promote collaborative learning?
- For example, math discourse and math problem solving skills & discourse.
- How can we create an online world-wide community of students engaging in chats about math with their peers?
“Doing Math”

- How do students “do math” together online in small groups?
- An empirical question!
What Methods Do Students Use?

- To form themselves into groups
- Define a problem to work on
- Start work
- Agree on how to proceed
- Bring in math resources
- Agree on solutions
- Close the problem solving
- Get to know each other
- Socialize, have fun, flirt
- Adapt to institutional setting
An Empirical Example

- Today we will look at how one small group did “making proposals” in a simple chat environment.
We define the method of group interaction in terms of a recurrent pattern of proposal bid/uptake.

Proposals are only effective as interactional phenomena, not as “expressions of internal mental representations” of individuals.
A “Failed Proposal”

- A failed attempt to initiate a proposal interaction
- A “breakdown” case
- Highlights conditions for success
- A promising place to look closely
Fostering Group Cognition

- Remember, our goal is to consider:
- How can computer support (CSCL) foster collaborative learning – knowledge building – group cognition?
The VMT Project

- Virtual Math Teams (VMT) at the Math Forum @ Drexel University.
- Research project – groups of 3-6 algebra & geometry students in chat rooms with challenging problems of math worlds to explore.
- “If two equilateral triangles have edge-lengths of 9 cubits and 12 cubits, what is the edge-length of the equilateral triangle whose area is equal to the sum of the areas of the other two?”
The Transcript

- A 3 ½ minute excerpt from an hour chat

- Contains several proposals
  - 6 proposal bids that get taken up by others
  - 1 failed proposal that is ignored in the chat
1. Avr (8:21:46 PM): Okay, I think we should start with the formula for the area of a triangle
2. Sup (8:22:17 PM): ok
5. pin (8:22:35 PM): yes
6. pin (8:22:37 PM): i concur*
7. pin (8:22:39 PM): concur*
8. Avr (8:22:42 PM): then find the area of each triangle
10. Sup (8:23:03 PM): the base and height are 9 and 12 right?
11. Avr (8:23:11 PM): no
12. Sup (8:23:16 PM): o
13. Avr (8:23:16 PM): that's two separate triangles
14. Sup (8:23:19 PM): ooo
15. Sup (8:23:20 PM): ok
17. Avr (8:23:27 PM): i think we have to figure out the height by ourselves
18. Avr (8:23:29 PM): if possible
19. pin (8:24:05 PM): i know how
20. pin (8:24:09 PM): draw the altitude'
21. Avr (8:24:09 PM): how?
22. Avr (8:24:15 PM): right
23. Sup (8:24:19 PM): proportions?
24. Avr (8:24:19 PM): this is frustrating
25. Avr (8:24:22 PM): I don't have enough paper
26. pin (8:24:43 PM): i think i got it
adjacency pair
other uptake
intersubjective small-group meaning making
coop-construction of sequentiality in doing math
Comparing Proposals

- 17, 18. Avr (8:23:29 PM): i think we have to figure out the height by ourselves … if possible
- 19. pin (8:24:05 PM): i know how
- 21. Avr (8:24:09 PM): how?
- 20. pin (8:24:09 PM): draw the altitude'
- 22. Avr (8:24:15 PM): right
- 24. Avr (8:24:19 PM): this is frustrating …
- 23. Sup (8:24:19 PM): proportions?
- 25. Avr (8:24:22 PM): […] I don't have enough paper
1. A bid for a proposal is made by an individual for the group to work on: “I think we should …."

2. An acceptance, confirmation or up-take is made on behalf of the group by a second person: “Ok,” “right”

3. There is an elaboration of the proposal by members of the group. The proposed work is begun, often with a secondary proposal for the first sub-step.
Problems with the Failed Proposal Bid

- A. No clear semantic, syntactic structure
- B. Timing within the flow of discussion
- C. No interruption of ongoing work
- D. Doesn’t elicit some kind of response
- E. Doesn’t specify work to be done
- F. Not based on a history of helpful work
Potential Helpful Computer Supports

- 1. A persistent and visible list of proposals
- 2. A persistent and visible summary of work
- 3. Perhaps a proof template that gets filled in
- 4. Representations of the developing problem, such as a shared drawing whiteboard for geometry problems
**PROBLEM STATEMENT:**
If two equilateral triangles have edge-lengths of 9 cubits and 12 cubits, what is the edge-length of the equilateral triangle whose area is equal to the sum of the areas of the other two?

**PROPOSALS:**
1. formula: $A = \frac{1}{2} b h$
2. area $A_1 = ?$
3. $b, h = 9, 12$
4. draw altitude
5. use proportions

**PROOF OUTLINE:**
- Given: $s_1=9, s_2=12$
- Given: $A_1 + A_2 = A_3$
- $A_1 = \frac{1}{2} s_1 h_1$
- $h_1 = ?$
- PROVE: $s_3 = ?$
Conclusions: Practical & Theoretical

- A group can advance through *math proposal adjacency pairs*
- It would help to have support to keep going without getting (a) stuck or (b) sidetracked
Paradigms of CSCL research

- Sending messages across a chasm thru a channel. How does knowledge in heads change?
- Co-constructing a shared world. How is group knowledge constructed?
Group Cognition

- The problem gets formed, developed, explored, incrementally solved through *interactions* (e.g., adjacency pairs)
- Individuals contribute proposals based on their personal perspectives, understanding, interpretation – ("I think")
- Individuals take up proposals based on their personal perspectives, understanding, interpretation -- ("I concur")
- But progress involves *group interaction* (on behalf of the group – "we")
Math proposal adjacency pairs establish shared knowledge, shared decision making and group meaning.

The interactive adjacency pair forms the unit of analysis, Vygotsky’s “cell-form”, the smallest element of meaning-making.

A failed proposal bid is not a meaningful part of the interaction; neither is “Ok” by itself.
The solution is co-constructed by the group; typically, a summary of the solution path is voiced by multiple participants.

Math problem solving is a high level cognitive accomplishment, here achieved by a group by means of interactive group methods using group resources (chat text, shared drawings, etc.).

Researchers can directly observe these methods and resources – they are not hidden in heads, requiring indirect outcome measurements.
Group learning and individual learning are not two different things here.

They are different aspects of one process: e.g., “I think that we should ….,” “Ok”

Individual cognitive resources are brought into group interactions; meaning is constructed inter-subjectively; group experiences, meanings and methods can be internalized.
Full paper:
www.cis.drexel.edu/faculty/gerry/publications/conferences/2005/earli

“Group Cognition” (the book) from MIT Press in the Spring – prepublication version available now:
www.cis.drexel.edu/faculty/gerry/mit

Journal of CSCL:
ijCSCL.org