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.

"Math Proposal Adjacency Pairs"

- 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

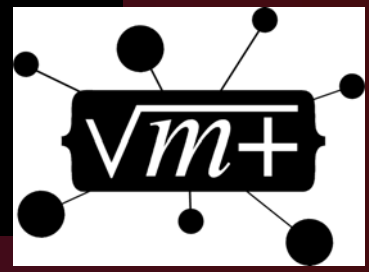
A “Failed Proposal”

- 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

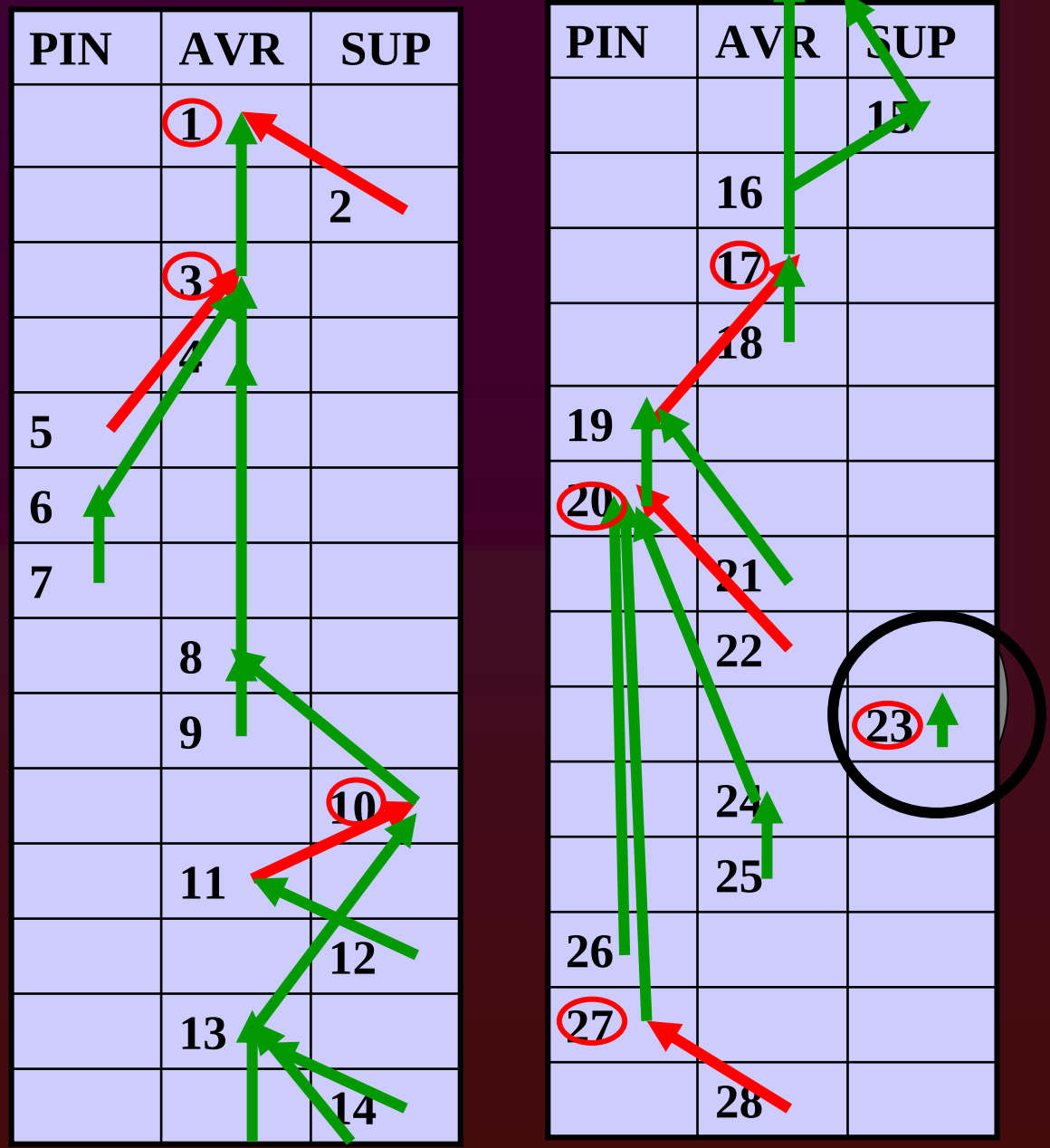


- Virtual Math Teams (VMT) at the Math Forum @ Drexel University.
- Research project – groups of 3-6 algebra & geometry students in chat rooms with challenging problems of math worlds to explore.
- *"If two equilateral triangles have edge-lengths of 9 cubits and 12 cubits, what is the edge-length of 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
  3. Avr (8:22:28 PM): A = 1/2bh
  4. Avr (8:22:31 PM): I believe
  5. pin (8:22:35 PM): yes
  6. pin (8:22:37 PM): i concue
  7. pin (8:22:39 PM): concur*
  8. Avr (8:22:42 PM): then find the area of each triangle
  9. Avr (8:22:54 PM): oh, wait
  10. Sup (8:23:03 PM): the base and heigth 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
  16. Avr (8:23:21 PM): right
  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

co-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**

Structure of a Proposal

- 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 on-going 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

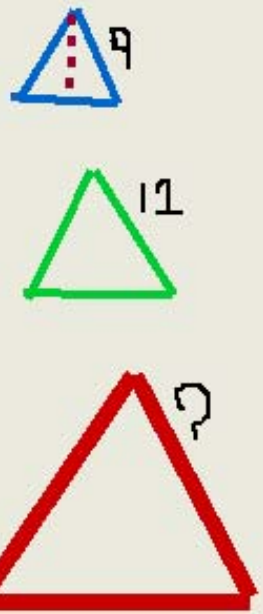
ConcertChat Prototype

WhiteboardChat: pin (EARLI)

Whiteboard:

Reference

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 ares of the other two?



PROPOSALS:

1. formula: A = 1/2 b h
2. area A1 = ?
3. b, h = 9, 12
4. draw altitude
5. use proportions

PROOF OUTLINE:
Given: s1=9, s2=12
Given: A1 + A2 = A3
A1 = 1/2 s1 h1
h1 = ?

PROVE: s3 = ?

Current users:

Avr
Sup
pin

Chat: (0)

pin (4:01 PM):
draw the altitude'

Avr (4:01 PM):
how?

Avr (4:01 PM):
right

pin (4:01 PM):
proportions?

Avr (4:02 PM):
this is frustrating

Avr (4:02 PM):
I don't have enough paper

pin (4:02 PM):
i think i got it

pin (4:02 PM):
its a 30/60/90 triangle

Avr (4:03 PM):
I see

pin (4:03 PM):
so whats the formula

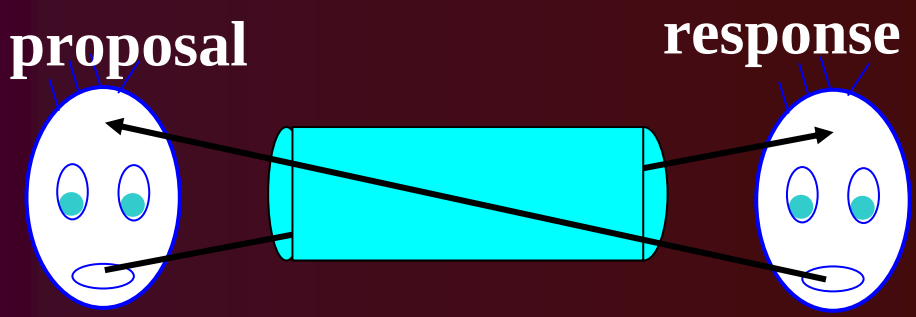
Message:

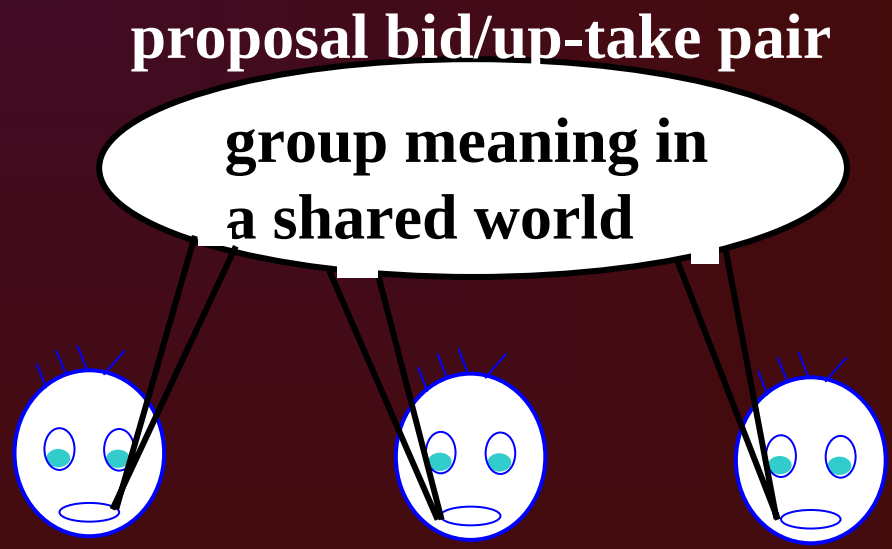
Conclusions: Practical & Theoretical

- 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")

Group Cognition, continued

- 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.

Group Cognition, continued

- 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 Cognition, continued

- 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