




*A joint presentation of the  
Virtual Math Teams Project  
at the Math Forum & the iSchool at Drexel  
and the Computer Science Department  
at Temple University*

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**Understanding  
computer-supported  
group cognition:  
Steps toward a science  
of virtual groups**

# Groups in Society

- Globalization: people work in distributed teams
- Knowledge society: more work is knowledge work, building shared knowledge in teams
- Networking: new opportunities for people to work and learn in teams
- Online collaboration is the new form of working — and working now means learning

# Support for Groups

- Single-user productivity tools: known technology & design methods (HCI)
- Social networking: new technology & haphazard design (Web 2.0 user-driven)
- Groupware:
  - CSCW computer-supported cooperative work
  - CSCL computer-supported collaborative learning
  - Much more complex HCI & design & dissemination issues

# Theories of Groups

- HCI was based on theories of cognitive psychology of the individual
- Now we need a science of the small group
- Especially the computer-mediated, online, virtual group
- To guide design of groupware

# Sciences of Groups

- Sciences of the individual
  - Social psychology
  - Educational psychology
  - Cognitive psychology
  - Organizational management
- Sciences of society
  - sociology, cultural anthropology, linguistics, etc.
- But no sciences of the small group!

# Cognition of Groups

- Psychology: group cognition is distortions of individual cognition
- AI: cognition is computation (by any substrate)
- Distributed cognition: individual extended by artifacts and external memories
- Group cognition: cognitive processes can arise through the interactions within a small group of participants — not just externalization of individual mental representations, but emergent result of situated interaction

# Preliminary Explorations of Groups

- Social psychology (but reductionist)
- Organizational management (ditto)
- Barron (2003), Cohen (2002), Nosek (2004), Schwartz (1995), Teasley & Roschelle (1993), Weick (2005)
- Stahl (2006) *Group Cognition: Computer Support for Building Collaborative Knowledge*, MIT Press
- Stahl (2009) *Studying Virtual Math Teams*, Springer

# The concept of group cognition

- “cogito ergo sum” confused relation of cognition and persistent human body
- Group cognition is not a matter of a physical group with a brain or persistent presence
- It is a matter of meaning making through the interaction of semantic artifacts (words, drawings, symbols, documents) situated in a structured network of other meaningful artifacts (situation, world, group context, indexical field)



# The concept of group cognition

- E.g., we can observe group cognition in a years old chat log — in the meaning making of the chat postings in the physical absence of any group participants
- The postings are read as meaningfully designed by humans to interact with other human postings
- But the cognitive accomplishments (e.g., problem solving) are in the interactions among the textual postings.

# The concept of group cognition

- The cognitive accomplishments emerge from the network of meaningful references built up by the individual textual postings
- E.g., planning, deducing, designing, describing, problem solving, explaining, defining, generalizing, representing, remembering and reflecting as a group

# The concept of group cognition

- The group as actor and group cognition are not physical objects or mental objects, but theoretical constructs resulting from analysis at the group level of description (like cultural norms and social rules at the social level)
- E.g., interpersonal trains of thought, shared understandings of diagrams, joint problem conceptualizations, common references, coordination of problem-solving efforts

# 3 Levels of Cognitive Description

- The *individual* actor (person) is described by (various theories in) cognitive psychology
- The *small-group* cognition is what emerges in the interactions among the utterances of the individual participants
- The social / cultural / *community* of practice / linguistic community is the institutionalized, persistent, shared results of the above
- The study of these different levels requires different Units of Analysis

# Mediation by small groups

- “Small groups are the engines of knowledge building. The knowing that groups build up in manifold forms is what becomes internalized by their members as individual learning and externalized in their communities as certifiable knowledge” [*Group Cognition*, p. 16].

# Toward a Science of Virtual Groups

- When small groups engage in cooperative problem solving or collaborative knowledge building, there are distinctive processes of interest at the *individual*, *small-group* and *community* levels of description, which interact strongly with each other.
- *The small-group level has no corresponding science*
- A science of virtual groups is particularly needed and possible

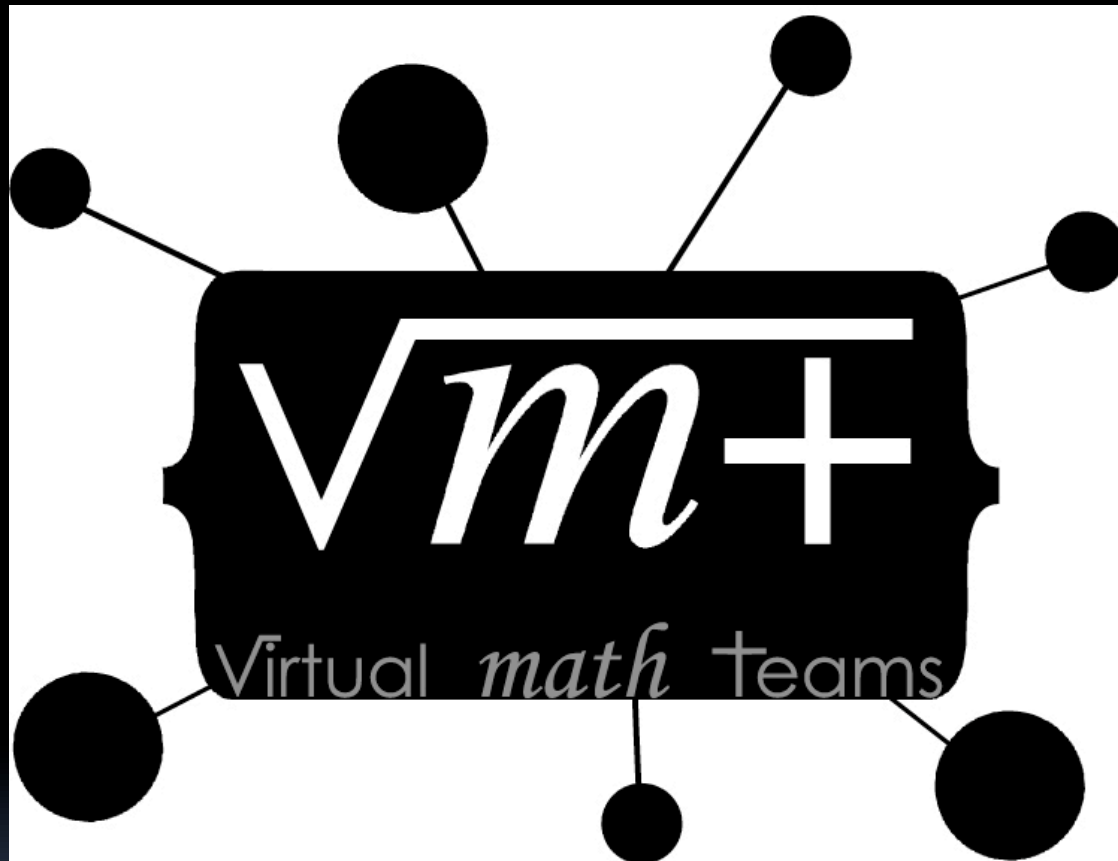
# How to Build a Science

- Define the domain of the science
- Explore the domain
- Capture a data corpus
- Select, adapt, refine and master methods for analyzing the data
- Organize analytic findings in a framework of theoretical conceptualizations

# VMT as a Model of a Science

- Design-based research: iterative cycles
- Spring Fest 2005, 2006, 2007 and others by collaborators, in my courses, misc trials
- Over 1,000 student-hours of data (370 sessions)
- Almost 200 academic research publications
- Preliminary explorations: *Group Cognition*
- Early Studies: *Studying Virtual Math Teams*





# Create the Domain

- Design-based research evolves the technology with the pedagogy, methods of analysis, usage feedback from data analysis and theory
- From off-the-shelf AOL Instant Messenger to VMT
- From Math Forum “problem-of-the-week” to four-hour open-ended math mini-world
- From one-shot chats to Spring Fest sessions to mini-curricula

# The VMT Lobby



## Virtual Math Teams

Head

[New to VMT?](#) --get started

[VMT help pages](#)

[Sandbox](#) --play and explore here

[See who is online now \(11\)](#)

[Create a new room](#)

[Find a VMT room](#)

[Find people](#)

[Find information](#)

[Set personal preferences](#)

### My Messages

most recent:

- [invitation from Gerry](#) (sent 09/15/06)
- [see you tomorrow](#) (sent 09/14/06)

### My Scheduled Rooms

most recent:

- [Geometry PoW-Shotgun Targets](#) (assigned 09/15/06)
- [Proof-Positive Numbers](#) (assigned 09/14/06)

### My Favorite Rooms

most recent:

- [Geometry World 3](#) (listed 09/15/06)
- [Patterns II](#) (listed 09/15/06)

## VMT Lobby

[List all rooms . . . .](#) [Refresh list of rooms](#)

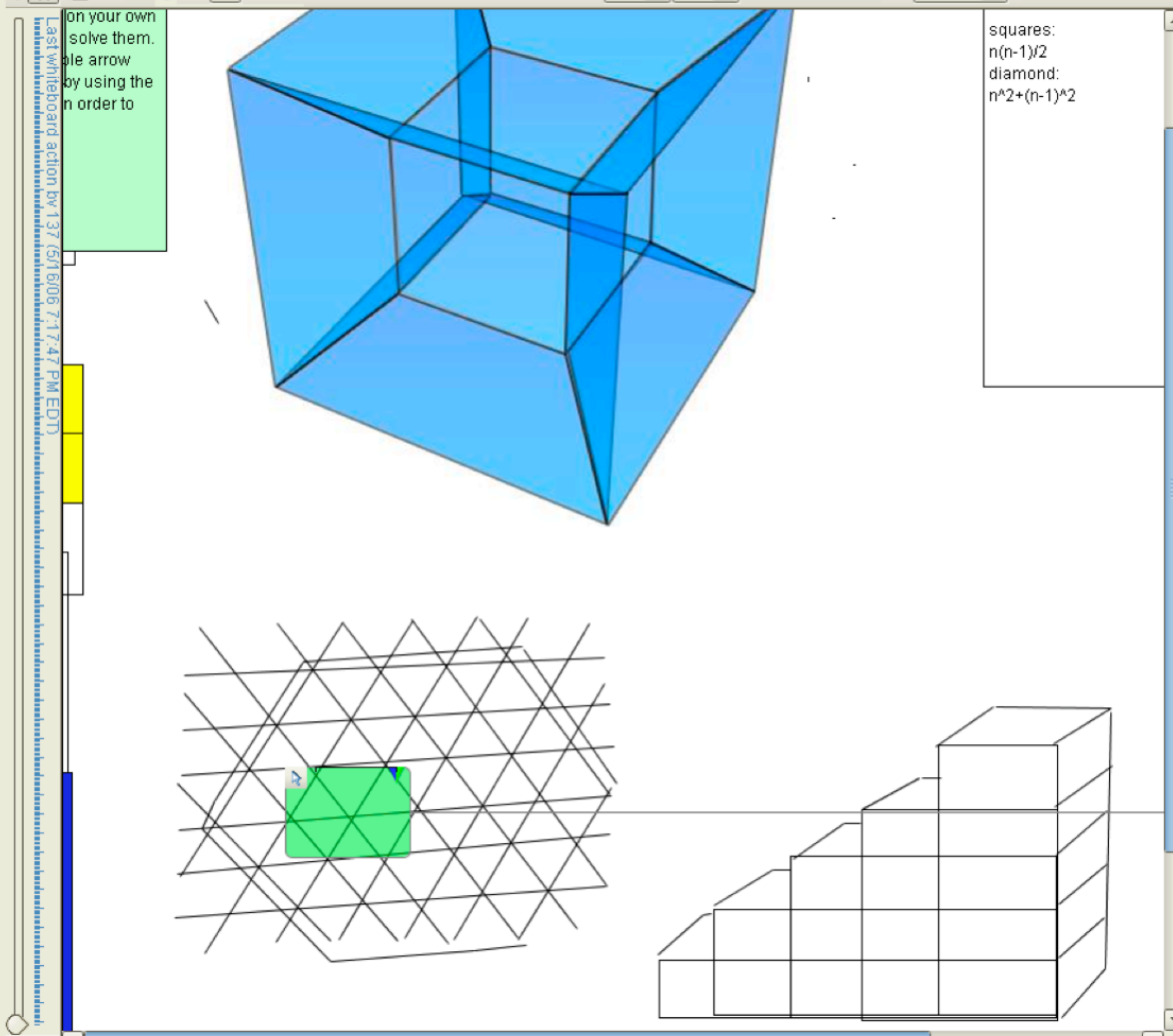
filter and order list of math chat rooms below

- [-] **Homework Collaborations** 1 topics
  - [-] **Homework** 2 rooms
    - [-] **Euclid's sandbox**
      - [Room Detail](#) closed room
    - [-] **Team E**
      - [Room Detail](#) open room
  - [-] **Patterns and Sequences** 1 topics
    - [-] **Patterns I** 3 rooms
      - [-] **Team B**
        - [Room Detail](#) closed room
      - [-] **Team C**
        - [Room Detail](#) invitational room
      - [-] **Team D**
        - [Room Detail](#) invitational room
    - [-] **Pre-Algebra** 2 topics
      - [-] **Jar of coins** 1 rooms
        - [-] **Team A**
          - [Room Detail](#) closed room
      - [-] **Patterns I** 3 rooms
        - [-] **Team B**
          - [Room Detail](#) closed room
        - [-] **Team C**
          - [Room Detail](#) invitational room
        - [-] **Team D**
          - [Room Detail](#) invitational room
      - [-] **Geometry** 1 topics
        - [-] **Patterns I** 3 rooms
          - [-] **Team B**
            - [Room Detail](#) closed room
          - [-] **Team C**
            - [Room Detail](#) invitational room
          - [-] **Team D**
            - [Room Detail](#) invitational room

# The VMT Chat Environment

ConcertChat Session Player - Room : channel:OID::1147211767857

**Whiteboard:**



on your own  
solve them.  
able arrow  
by using the  
in order to

Last Whiteboard action by 137 (5/16/06 7:17:47 PM EDT)

squares:  
 $n(n-1)/2$   
diamond:  
 $n^2+(n-1)^2$

**Current users:**

137
Jason
nan
qwertyuiop

**Chat: (0)**

does everyone know what other people are doing?

- 137 5/16/06 7:14:25 PM EDT: Yes?
- qwertyuiop 5/16/06 7:14:25 PM EDT: no-just making triangles
- 137 5/16/06 7:14:33 PM EDT: I think..
- Jason 5/16/06 7:14:34 PM EDT: yeah
- nan 5/16/06 7:14:46 PM EDT: good 😊
- qwertyuiop 5/16/06 7:14:51 PM EDT: triangles are done
- 137 5/16/06 7:15:08 PM EDT: So do you want to first calculate the number of triangles in a hexagonal array?
- qwertyuiop 5/16/06 7:15:45 PM EDT: What's the shape of the array? a hexagon?
- 137 5/16/06 7:16:02 PM EDT: Ya.
- qwertyuiop 5/16/06 7:16:15 PM EDT: ok...
- Jason 5/16/06 7:16:41 PM EDT: wait- can someone highlight the hexagonal array on the diagram? i dont really see what you mean...
- Jason 5/16/06 7:17:30 PM EDT: hmm.. okay
- qwertyuiop 5/16/06 7:17:43 PM EDT: oops
- Jason 5/16/06 7:17:44 PM EDT: so it has at least 6 triangles?
- Jason 5/16/06 7:17:58 PM EDT: in this, for instance

**Message:**

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# The VMT Tabbed Environment

The screenshot displays a web browser window with a tabbed interface. The active tab is labeled 'Material:'. Below the tab, there are navigation buttons: 'Workspace' (highlighted in green), 'Summary', 'Topic', 'Wiki', 'Browser', and 'Help'. The browser's address bar shows 'http://vmt.mathforum' and includes navigation controls like 'Forward', 'Back', 'Refresh', and 'Stopp'. A 'Log in / create account' link is visible above the main content area.

The main content area features a logo with the text 'vm+' and a 'Resources' section. The text under 'Resources' reads: 'Probability, in common terms, is the chance that something is likely to happen. Probability theory is the formal mathematical study of the principles and rules that help us understand how probability works. You can find the probability problems and strategies that the VMT community has worked on in the *main Probability page*.'

Below the text is a 'Contents [hide]' section with a list of links:

- 1 Introduction to Probability
- 2 Basic Terminology of Probability Theory
- 3 Probability of an event
- 4 Basic Probability Theorems
- 5 Conditional Probability
- 6 Independent Events
- 7 A Review of Concepts on Permutations and Combinations
- 8 Probability in Our Lives
- 9 Some Sample Questions and Answers on Probability from Aks Dr. Math Archives
- 10 Other Resources

On the left side of the browser window, there are several utility sections:

- navigation**:
  - VMT Lobby
  - Wiki Main Page
  - Recent changes
  - Help
- search**: A search input field with 'Go' and 'Search' buttons.
- toolbox**:
  - What links here
  - Related changes
  - Upload file
  - Special pages
  - Printable version
  - Permanent link

On the right side of the browser window, there is a 'Current users:' section showing 'Gerry' and a 'Chat (35...)' window. The chat window contains several messages:

- Elizabeth** 5/17/07 9:01:19 PM EDT: It's easy to recognize and easy to see.
- bku22** 5/17/07 9:01:51 PM EDT: don't for get about errors
- bku22** 5/17/07 9:04:55 PM EDT: I think with question 9 we want to answer the follow question; Does this system help a user recover from a error that they made. And if so how
- bku22** 5/17/07 9:07:42 PM EDT: this sound good
- bku22** 5/17/07 9:09:28 PM EDT: Seven and ten are ready
- bku22** 5/17/07 9:12:05 PM EDT: i agree
- bku22** 5/17/07 9:13:05 PM EDT: Olivia how is six it looks like someone stop in the middle of a sentence
- Olivia** 5/17/07 9:13:53 PM EDT: yea im on it whoops

Below the chat window is a 'Message:' section with the text: 'Take a look at that definition of probabil'.

At the bottom of the browser window, the copyright notice reads: '© 2005-2006 Fraunhofer IPSI, Darmstadt, Germany'.

# The VMT Wiki



## navigation

- [VMT Lobby](#)
- [Wiki Main Page](#)
- [Recent changes](#)
- [Help](#)

## search

## toolbox

- [What links here](#)
- [Related changes](#)
- [Upload file](#)
- [Special pages](#)
- [Printable version](#)
- [Permanent link](#)

[Gerry](#) [my talk](#) [my preferences](#) [my watchlist](#) [my contributions](#) [log out](#)

[article](#) [discussion](#) [edit](#) [history](#) [move](#) [watch](#)

## Probability

Here are a set of challenges related to probability problems. **You can contribute** by adding your ideas about applying a strategy to a problem (adding content to a P#S# page), proposing a new strategy (adding a new column) or adding a new challenge (row).

Probability Strategies & Problems	S1. Drawing balls from a jar	S2. Solve Complementary Problem	S3. Enumerate & Organize your cases	S4. Use a Tree Diagram	S5. New Strategy
<a href="#">P1. The sock drawer</a>	<a href="#">P1S1</a>	<a href="#">P1S2</a>	<a href="#">P1S3</a>	<a href="#">P1S4</a>	<a href="#">P1S5</a>
<a href="#">P2. Box with three cards</a>	<a href="#">P2S1</a>	<a href="#">P2S2</a>	<a href="#">P2S3</a>	<a href="#">P2S4</a>	<a href="#">P2S5</a>
<a href="#">P3. Seating arrangements</a>	<a href="#">P3S1</a>	<a href="#">P3S2</a>	<a href="#">P3S3</a>	<a href="#">P3S4</a>	<a href="#">P3S5</a>
<a href="#">P4. Baseball World Series</a>	<a href="#">(P4-S1 Example)</a>	<a href="#">(P4-S2 Example)</a>	<a href="#">(P4-S3 Example)</a>	<a href="#">(P4-S4 Example)</a>	<a href="#">P4S5</a>
<a href="#">P5. Duck hunters</a>	<a href="#">P5S1</a>	<a href="#">P5S2</a>	<a href="#">P5S3</a>	<a href="#">P5S4</a>	<a href="#">P5S5</a>
<a href="#">P6. Clock hands</a>	<a href="#">P6S1</a>	<a href="#">P6S2</a>	<a href="#">P6S3</a>	<a href="#">P6S4</a>	<a href="#">P6S5</a>
<a href="#">P7. Length of Random Chords</a>	<a href="#">P7S1</a>	<a href="#">P7S2</a>	<a href="#">P7S3</a>	<a href="#">P7S4</a>	<a href="#">P7S5</a>
<a href="#">P8. New Problem</a>	<a href="#">P8S1</a>	<a href="#">P8S2</a>	<a href="#">P8S3</a>	<a href="#">P8S4</a>	<a href="#">P8S5</a>

If you need them, here are some [resources for probability](#)

Categories: [ProblemSolving](#) | [VMT](#)

# The VMT Replayer

ConcertChat Session Player - Room : channel:OID::1147211756291

Whiteboard:

top/bottom:  $2n(n+1)$

Derived from

$((1+N)*N/2 + N) * 2$

$\sum_{n=1}^N = 4n(n+1) + (n+1)$

$(n^2 + (n-1)^2) * 2 + n * 3 - 2$

by clicking on the double arrow icon above the chat scroll bar. You can look through the history of the whiteboard by using the scroll bar all the way on the left (be sure to scroll all the way down to the present in order to draw anything new.)

You did a great job of defining a challenging problem and solving it by using a combination of methods that were well suited to the problem. And you shared what you did with the other groups in the wiki.

You noticed that stating the problem and making it clear to everyone is a big part of working on a problem. In going to 3-D, you selected a particular kind of pyramid. How would your problem change if you had two flat sides, with each layer in a corner of the layer underneath, so that some cube faces and edges (sticks) were shared between layers?

Can you explain your formula for the number of sticks so that someone in a different group can see how you got it by breaking each layer into its top surface, bottom and middle and then counting the horizontal and vertical sticks separately?

Do you understand how team C got its formulae for the diamond pattern of squares? What if they had a diamond pattern of diamonds (just rotate the squares 45 degrees)?

What shapes make mathematically interesting patterns in 2-D or in 3-D?

Current users:  
Aznx  
Gerry  
Quicksilver  
bwang8

Chat (0)

Quicksilver 5/16/06 7:44:17 PM EDT: let ask xander

1 Gerry 5/16/06 7:45:18 PM EDT: I assume N is the stage in the pattern

Aznx 5/16/06 7:45:29 PM EDT: What do you mean?

Quicksilver 5/16/06 7:45:35 PM EDT: That is twelve extra squares in a five by five square

Aznx 5/16/06 7:45:39 PM EDT: I'm confused how the pattern grows

Aznx 5/16/06 7:45:50 PM EDT: Oh, I get it now

Aznx 5/16/06 7:45:56 PM EDT: I was on the right track =P

1 Gerry 5/16/06 7:45:59 PM EDT: Just like in the original problem on the Topic

Gerry 5/16/06 7:47:12 PM EDT: Stage N=1 is one square

Gerry 5/16/06 7:47:27 PM EDT: Stage N= 2 is a cross of 5 squares

Quicksilver 5/16/06 7:47:37 PM EDT: Ok

1 Gerry 5/16/06 7:48:00 PM EDT: Stage N=3 is the bigger figure with 13 squares

Quicksilver 5/16/06 7:48:08 PM EDT: Stage N=3 is a cross of 9 squares or 13?

Aznx 5/16/06 7:48:23 PM EDT: 13

Aznx 5/16/06 7:48:32 PM EDT: i thnk

Quicksilver 5/16/06 7:48:42 PM EDT: Because those extra four are tricky

1 Gerry 5/16/06 7:48:46 PM EDT: you could define the sequence either way

Quicksilver 5/16/06 7:48:54 PM EDT: yeah

Quicksilver 5/16/06 7:49:01 PM EDT: but it has to be constant

1 Gerry 5/16/06 7:49:05 PM EDT: which did they do? Which is more interesting mathematically?

Aznx 5/16/06 7:49:29 PM EDT: 13

Aznx 5/16/06 7:49:34 PM EDT: is much more interesting =P

1 Quicksilver 5/16/06 7:49:34 PM EDT: it doesn't

Message:

bwang8, Aznx, Quicksilver are typing

Speed: 1

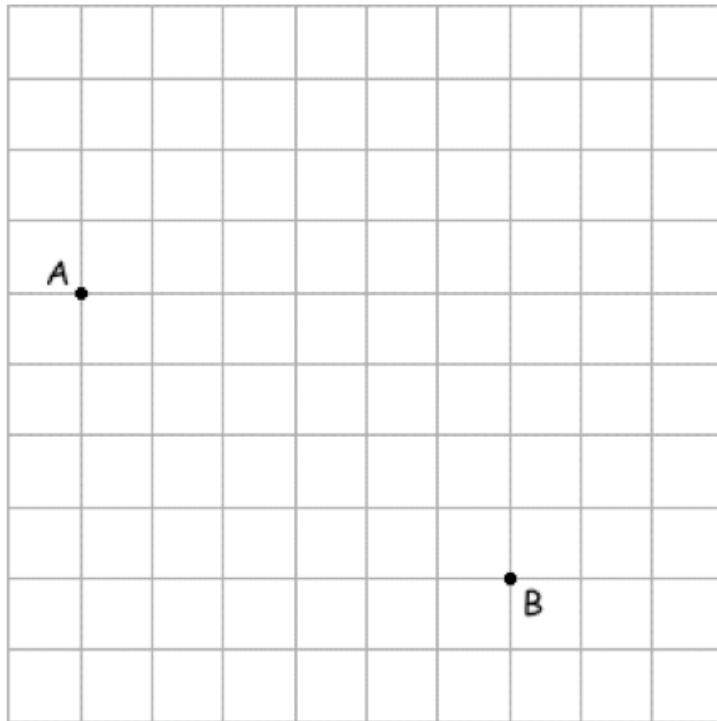
Time to previous: -0:01 (Awareness info)  
Current action at: 7:57:41 PM (Message by: bwang8)  
Time to next: 0:00 (Awareness info)

# Spring Fest 2005

**There are some situations where you can only travel along the lines of a grid - for example, driving in a city like Manhattan or Philadelphia. What difference does this make?**

**In the picture below, what is the length in grid units of the shortest path you can travel between the two points, A and B, staying along the grid?**

**How many paths of that length connect A and B?**





# Spring Fest 2006



(1) 4 sticks, 1 square



(2) 10 sticks, 3 squares



(3) 18 sticks, 6 squares

<b>N</b>	<b>Sticks</b>	<b>Squares</b>
1	4	1
2	10	3
3	18	6
4	?	?
5	?	?
6	?	?
...	...	...
<b>N</b>	?	?

# Collect the Data

					Log of Team B	VMT Spring Fest	2006	
Line #	Date	Time Start Typing	Time Posting	Duration	Bwang8	Aznx	Quicksilver	G
1322	5/18/06	19:19:46	19:19:47	0:00:08		Yeah.		
1323	5/18/06	19:19:48	19:19:55	0:00:10		We can always double check, and it's darn right.		
1324	5/18/06	19:19:56	19:20:05	0:00:10		So we solve it by really looking at a bigger picture.		
1325	5/18/06	19:20:10	19:20:15	0:00:05			or bigger square in this case	
1326	5/18/06	19:20:12	19:20:20	0:00:03		In this case, the "square" itself.		
1327	5/18/06	19:20:22	19:20:23	0:00:11		Yeah.		
1328	5/18/06	19:19:52	19:20:34	0:00:09	i think the 4 corner is growing like this			
1329	5/18/06	19:20:35	19:20:43	0:00:05	0,1,3,6,10			
1330	5/18/06	19:20:44	19:20:48	0:00:03	what is the pattern			
	5/18/06	19:20:49	19:20:51	0:00:05	[user erased message]			
1331	5/18/06	19:20:53	19:20:56	0:00:02		Triagnular numbers.		
1332	5/18/06	19:20:52	19:20:58	0:00:02			triangular numbers!	
1333	5/18/06	19:20:59	19:21:00	0:00:03	yep			
1334	5/18/06	19:20:57	19:21:03	0:00:07		We had already figured that out.		
	5/18/06	19:21:08	19:21:10	0:00:00			[user erased message]	
1335	5/18/06	19:21:01	19:21:10	0:00:01	we can use the equation from session 1			
1336	5/18/06	19:21:10	19:21:11	0:00:09			yes	
1337	5/18/06	19:21:19	19:21:20	0:00:16		Yup.		
1338	5/18/06	19:21:35	19:21:36	0:00:03	$n(n+1)/2$			
	5/18/06		19:21:39	0:00:02			[Quicksilver moved some object/s ]	
	5/18/06		19:21:41	0:00:02			[Quicksilver moved some object/s ]	
	5/18/06		19:21:43	0:00:04			[START:TextEditing]	
	5/18/06		19:21:47	0:00:07			[END:TextEditing]	
	5/18/06		19:21:54	0:00:02		[Aznx moved some object/s ]		
1339	5/18/06	19:21:44	19:21:56	0:00:01	$4*n(n+1)/2=$ the four corners			
1340	5/18/06	19:21:53	19:21:57				this right?	

# Establish a Data Corpus

- 1,000 student-hours of naturalistic usage
- Variety of scenarios: math problems, ages, group sizes, lengths of sessions, technologies
- Detailed logs
- Replayer to view and study interactions
- No data on individual factors or cultural
- Capture everything that entered into the interaction and was shared in the group interaction — available in detail in data

# Analyze the Data

- Inspired by conversation analysis and ethnomethodology
- Use the replayer
- Select excerpts of interest
- Threading analysis
- Identify methods of group interaction
- Identify group cognitive achievements

# Represent the Data

line	Anna	Quicksilver	Bwang	reference
1393		(a) was define the problem, (b) was the solution which we got...		feedback text-box on whiteboard
1394			we calculated the # of square if the diamond	drawing of diamond with red corners on whiteboard
1395	We can define the problem.			
1396	We got the solutions			
1397		yes		
1398		the added corners		
1399	But I'm not sure how to explain how we got to the solutions,			
1400		to make a square		
1401	I'm just not sure how to explain it.			
1402		and we found those were triangular numbers		a previous discussion of "triangular" numbers
1403	Well, I can explain the second			
1404		step by step		formula for # of sticks
1405		NO!		
1406		we don't know the second		
1407	It was done through the method of finding the pattern of triangular			
1408	Yes we do.			
1409		?		
1410	Suppose their second formula is our third.			
1411		That was taem c's tho		Team C wiki page
1412	No.			
1413	They didn't do.			
1414	The number of squares			
1415		h!		
1416	or the find the big square			
1417		that formula		
1418		i thot u meant the other one		
1419		teach that is ours		
1420			point formula out with the tools so we don't get confused	the YMT referencing tool
1421	So we're technically done with all of it right?			
1422		this is ours		big square: $(2n-1)^2$ corners: $n(n+1)/2^2 - 4$ $(2n-1)^2 - n(n+1)/2^2 + 4$
1423		all right lets put it on the wiki		the wiki pages
1424	That is theirs.			$n^2 + (n-1)^2 + 2 + n^3 - 2$
1425		adn lets clearly explain it		
1426	Bwang you do it. =P			

# Some Initial Findings

- Problem solving discourse is driven by proposal/response interactions
- Groups construct a joint problem space through interactions that involve temporality, positioning and concepts
- VMT participants intricately coordinate visual, narrative & symbolic reasoning/inscriptions
- Information questioning proceeds through interaction to elaborate what is sought
- Groups construct an indexical field that lends contextual meaning to elliptical utterances

# Some Initial Theory

- Important cognitive processes occur distinctively on individual, group and community levels of description
- They are appropriately studied at the corresponding unit of analysis
- The levels influence each other, but are not reducible to each other
- Often, group cognition can be best observed, because it takes place publically and explicitly and has not yet been reified or institutionalized

# Scientific Issues

- A rigorous science can take many forms — e.g., predictive mathematical physics vs. case-based descriptive history — but it is generally concerned with issues of:
  - Objectivity
  - Reliability
  - Generalizability
  - Etc.



# Objectivity

- The data is automatically logged
- No selective perspective (camera angles, lighting, choice of heard or remembered)
- No interpretive transcription
- Logs can include relevant details of interaction
- Replayer displays everything that was shared by the participants
- Replayer allows extremely detailed analysis

# Reliability

- Data sessions with multiple analysts
- Using logs, replayer
- Discuss individual chat postings & moves
- More than standard inter-rater reliability



# Generalizability

- Analyst group has experience with many chat and classroom math interactions
- Ethnomethodology argues that utterances and other interactive moves are “accountable”
  - The way they are organized displays to others the means to recognize them as what they are
- Conversation analysis argues that there are necessarily general methods people use
  - Members of a linguistic community share recognizable and identifiable methods for accomplishing everyday interaction tasks

# Making Group Proposals

- For instance, in F2F social conversation, groups use various “adjacency pairs”
  - Question/answer, greeting/greeting, proposal/acceptance, ....
- In VMT, math problem solving generally proceeds with math proposals followed by acceptance, question, rejection, alternate, etc.

# Establishing Group Order

- Just as sociology (incl. ethnomethodology, activity theory, anthropology) studies how communities establish, maintain, reproduce and evolve social order
- A theory of group cognition can study how small virtual groups establish, maintain, reproduce and evolve their interpersonal order and how they can accomplish cognitive tasks like working on mathematics

# Summary

- There is a scientific lacuna between sciences of the individual and sciences of communities
- There are important cognitive achievements at the small-group level of description
- These should be studied by a science of groups
- Online small groups are becoming increasingly possible and important in the global networked world
- A science of virtual groups could help the design of collaborative software for working and learning

# Future Work

- Scale up to regular Math Forum service
- Analysis of four-days of sessions
- Dynamic geometry (geometer's sketchpad)
- Use with math teacher professional development
- Encourage collaborators to use and study VMT
- Contribute to a science of virtual groups

# For Further Information

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- Slides and pdf of this paper:  
<http://GerryStahl.net/pub/group2009.pdf> and  
<http://GerryStahl.net/pub/temple2009ppt.pdf>

