The School of Education and the Virtual Math Teams Project present

Gerry Stahl

Group cognition: Research toward a scientific foundation for computer-supported collaborative learning

Groups in Society

- Globalization: people work and learn 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 learning

Support for Groups

- Single-user productivity tools: known technology & design methods (HCI)
- Social networking: new technology & haphazard design (Web 2.0 user-driven)
- Software of group learning:
  - CSCL computer-supported collaborative learning
  - Much more complex HCI & design & dissemination issues
  - Much progress in virtual community social computing but not in small-group collaboration in past 20 years

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 instructional technology for collaborative learning we need to understand how groups build knowledge, solve problems, pursue inquiry, explore, conceive, design

Sciences of Groups

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

Sciences of Groups

- Of course, there has been research and theories about small groups
  - What are the advantages and dangers?
  - Do students learn more in groups?
  - What about group size, heterogeneity, gender, socio-economics, …?
- But not about *how* groups achieve cognitive goals

Sciences of Groups

- Lots of talk of "meaning making" and "sense making", but no analysis of *how* this takes place

- My claim: we can observe the *interactional co-construction of group meaning* in small groups
- (Meaning making and learning cannot be observed in individual or community cognition – making these contested and mysterious)

Cognition of Groups

- Psychology: group cognition is distortions of individual cognition ("group think", "mass")
- AI: cognition is computation (by any substrate)
- Distributed cognition: individual extended by artifacts and external memories
- Group cognition (my working hypothesis): 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

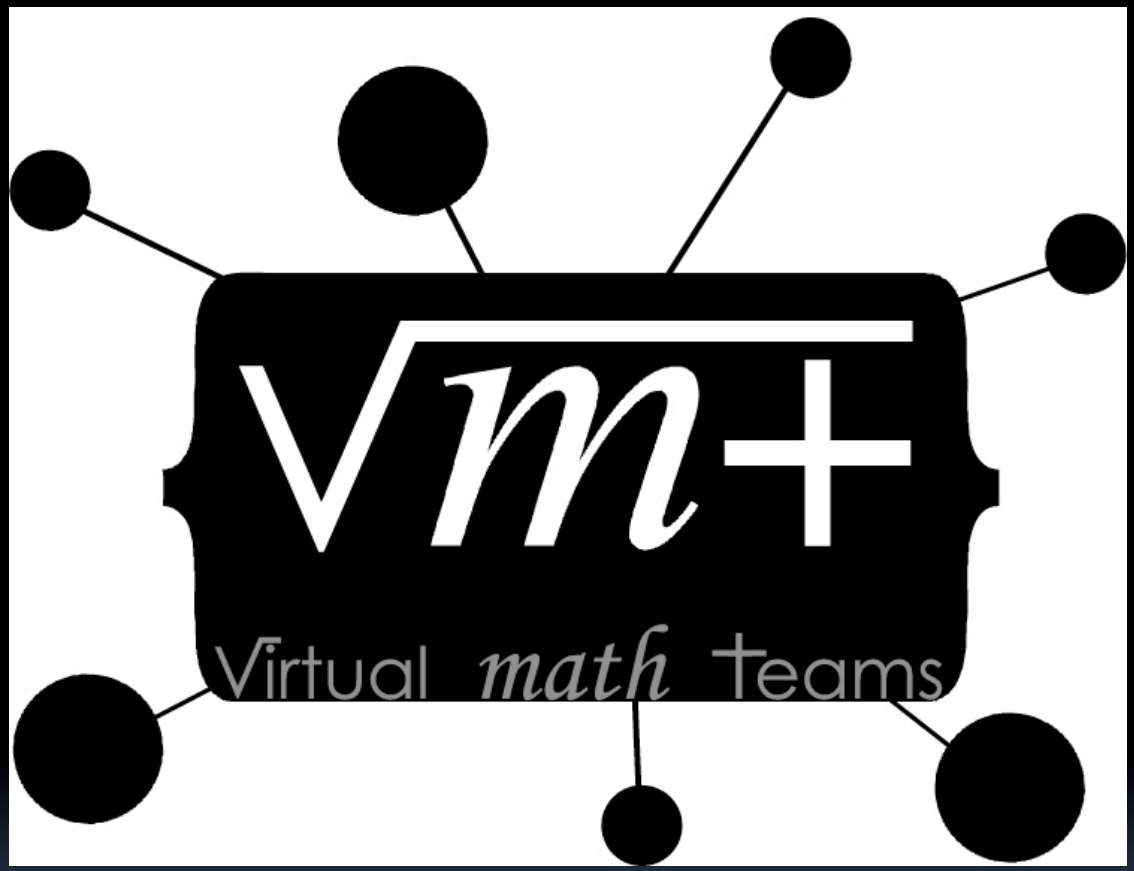
- When small groups engage in cooperative problem solving or collaborative knowledge building, there are distinctive processes of interest at the ***individual***, ***small-group*** and ***community*** levels of description, which interact strongly with each other.
- *The small-group level has no corresponding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

How to Build a Science: 5 steps

1. Define the domain of the science
2. Explore the domain
3. Capture a data corpus
4. Select, adapt, refine and master methods for analyzing the data
5. 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 2,000 student-hours of data (576 sessions)
- Almost 200 academic research publications
- Preliminary explorations: *Group Cognition*
- Early Studies: *Studying Virtual Math Teams*

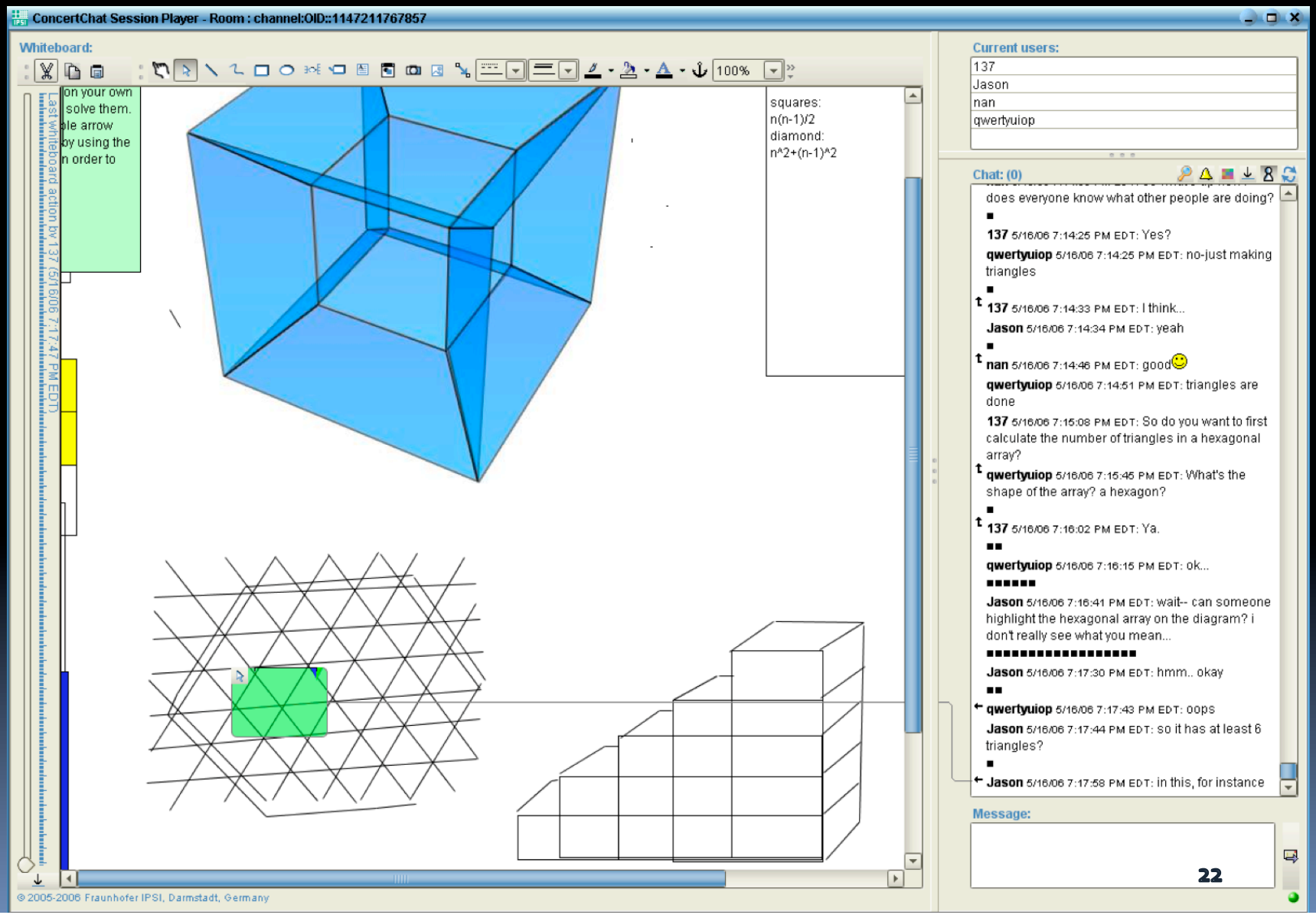

√m+
Virtual math Teams

1. Create the Domain

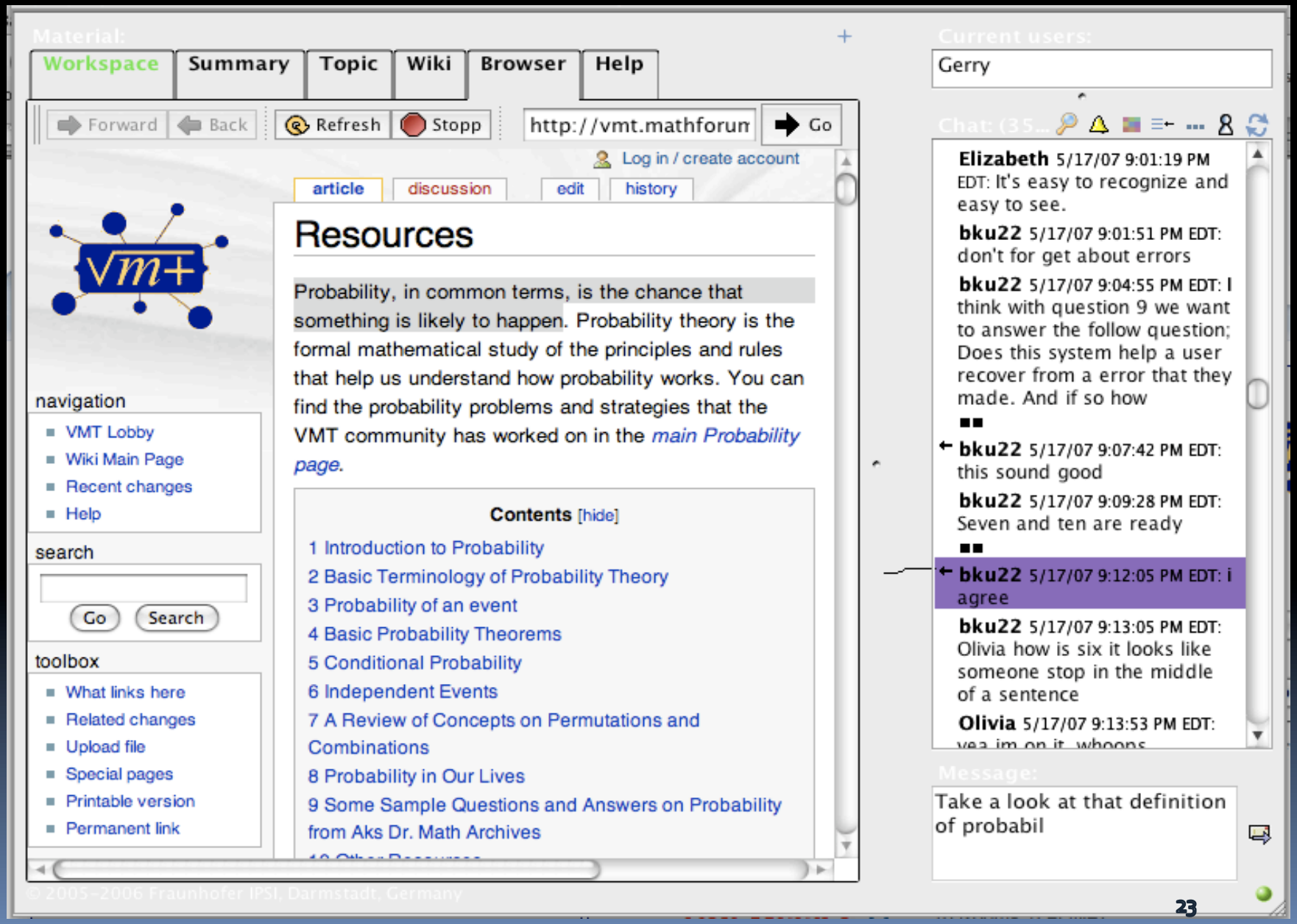
- Design-based research evolves the technology with the pedagogy, methods of analysis, usage feedback from data analysis and theory
- From off-the-shelf AOL Instant Messenger to VMT
- From Math Forum "problem-of-the-week" to four-hour open-ended math mini-world
- From one-shot chats to Spring Fest sessions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

The VMT Lobby

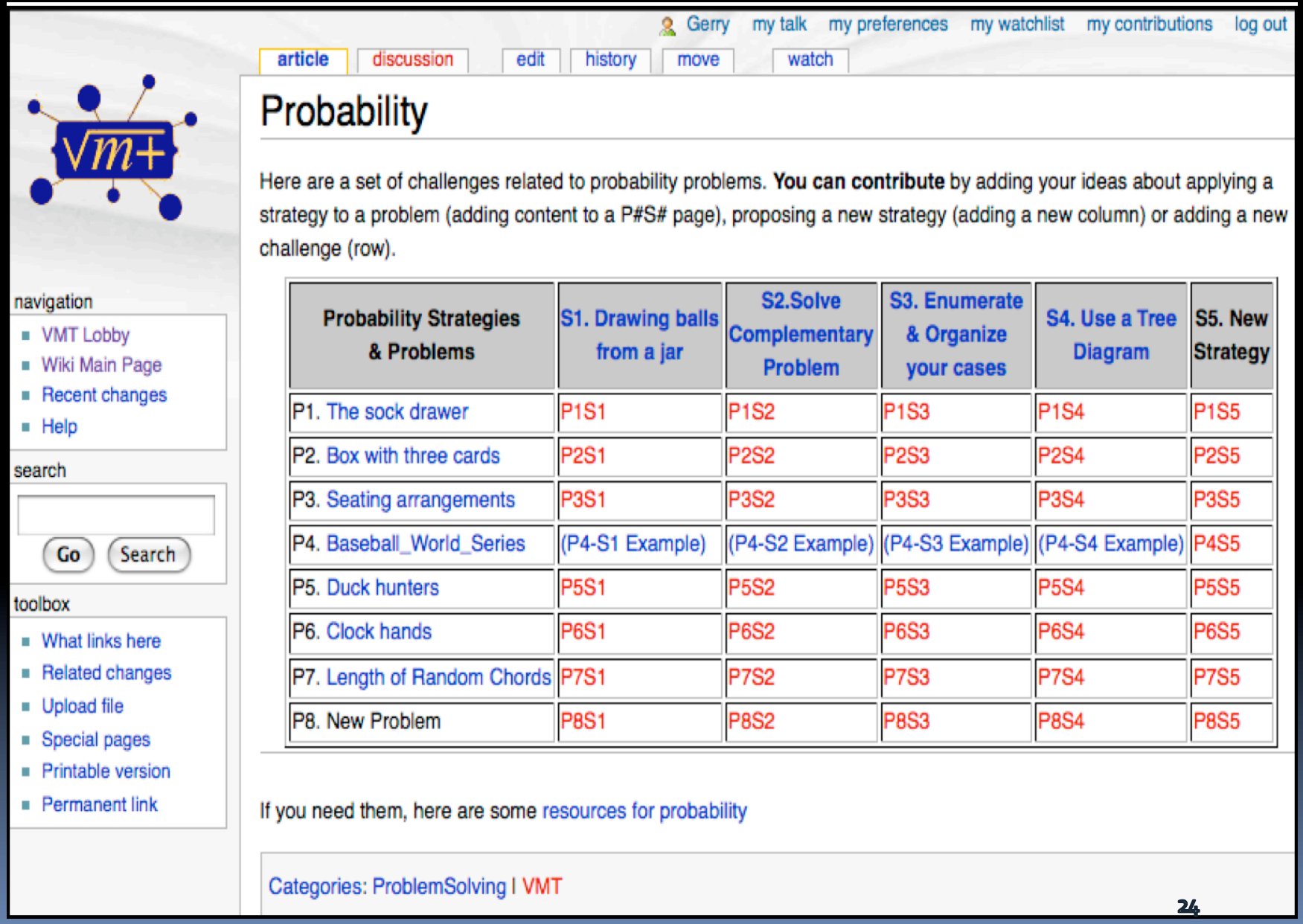
The VMT Chat Environment



The VMT Tabbed Environment



The VMT Wiki



Gerry my talk my preferences my watchlist my contributions log out

article | discussion | edit | history | move | watch

navigation
- VMT Lobby
- Wiki Main Page
- Recent changes
- Help

search

Go Search

toolbox
- What links here
- Related changes
- Upload file
- Special pages
- Printable version
- Permanent link

Probability

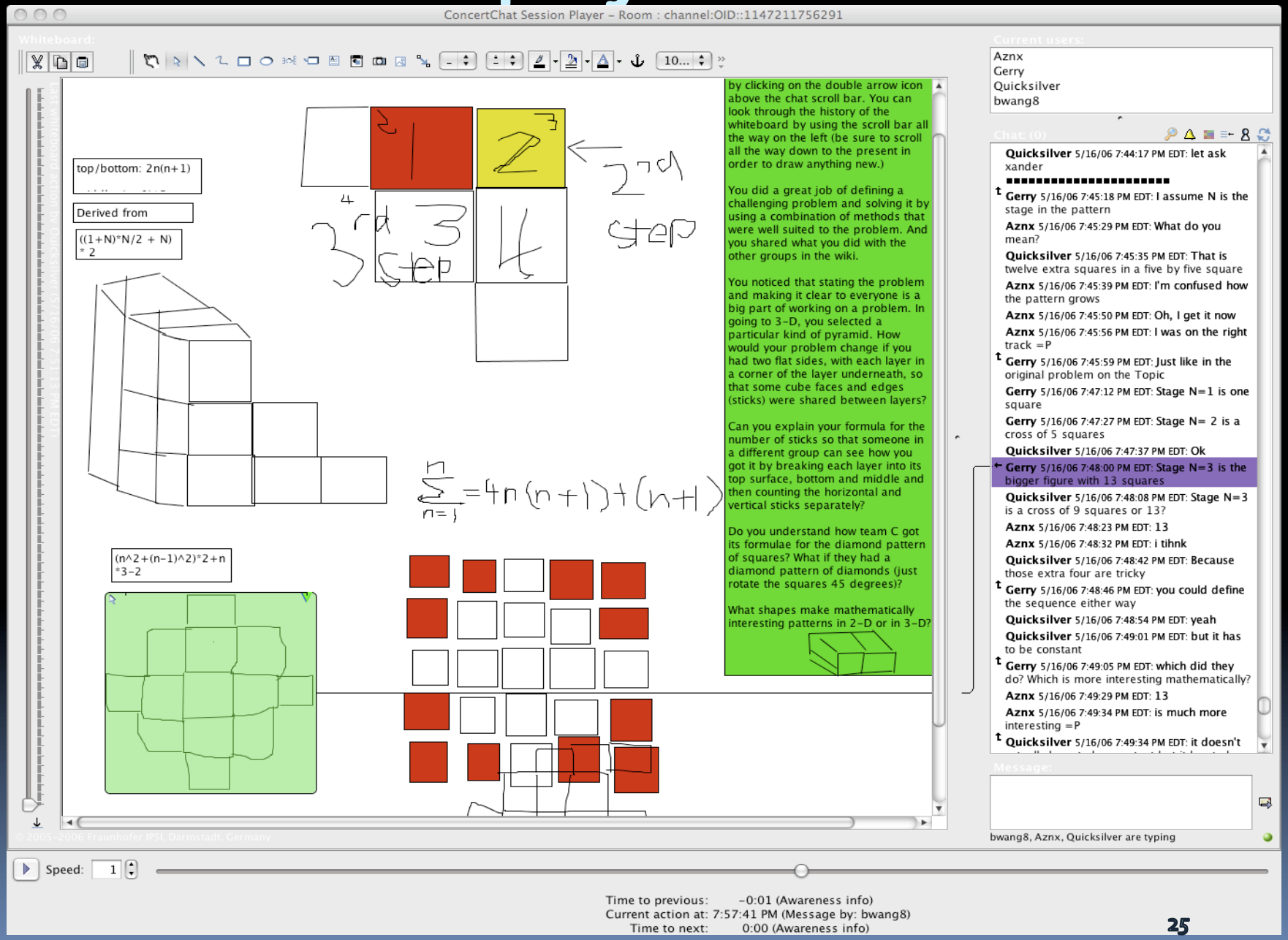
Here are a set of challenges related to probability problems. **You can contribute** by adding your ideas about applying a strategy to a problem (adding content to a P#S# page), proposing a new strategy (adding a new column) or adding a new challenge (row).

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
P1. The sock drawer	P1S1	P1S2	P1S3	P1S4	P1S5
P2. Box with three cards	P2S1	P2S2	P2S3	P2S4	P2S5
P3. Seating arrangements	P3S1	P3S2	P3S3	P3S4	P3S5
P4. Baseball_World_Series	(P4-S1 Example)	(P4-S2 Example)	(P4-S3 Example)	(P4-S4 Example)	P4S5
P5. Duck hunters	P5S1	P5S2	P5S3	P5S4	P5S5
P6. Clock hands	P6S1	P6S2	P6S3	P6S4	P6S5
P7. Length of Random Chords	P7S1	P7S2	P7S3	P7S4	P7S5
P8. New Problem	P8S1	P8S2	P8S3	P8S4	P8S5

If you need them, here are some resources for probability

Categories: ProblemSolving | VMT

The VMT Replayer

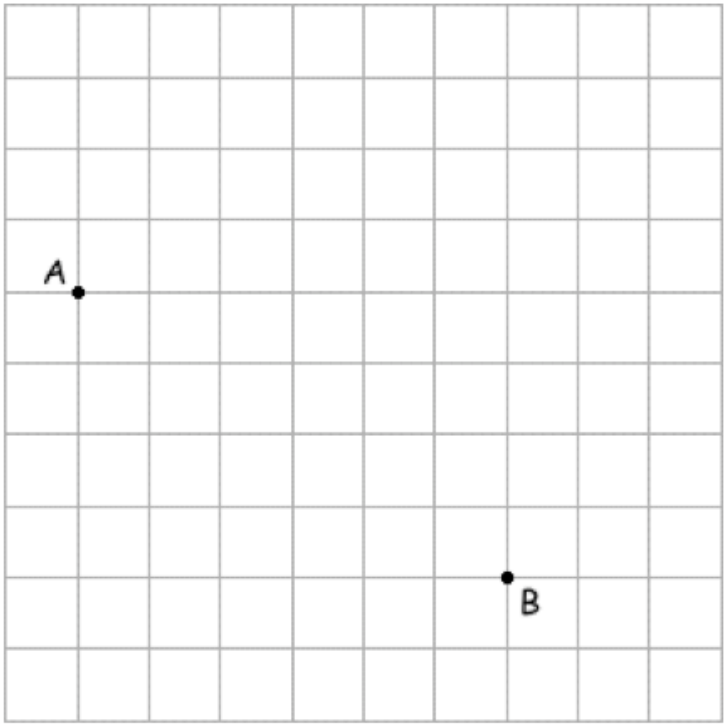


Spring Fest 2005

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

N	Sticks	Squares
1	4	1
2	10	3
3	18	6
4	?	?
5	?	?
6	?	?
...	...	...
N	?	?

2. Explore & Collect 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?	

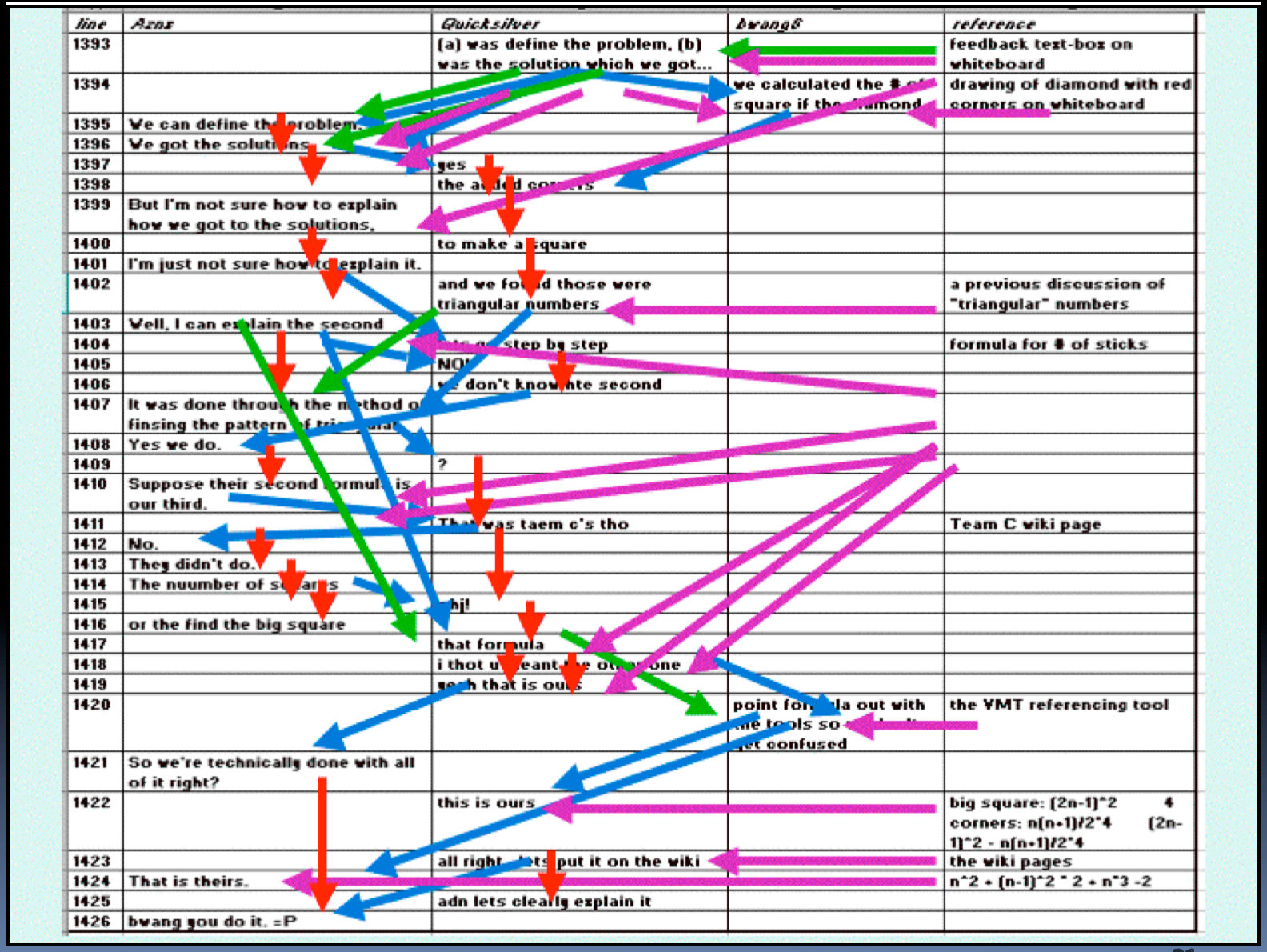
3. Establish a Data Corpus

- 2,000 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

4. 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	bwang6	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		ges		
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 finsing the pattern of tri			
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 nuumber of squares			
1415		hj!		
1416	or the find the big square			
1417		that formula		
1418		i thot u meant the other one		
1419		yeah that is ours		
1420			point formula out with the tools so get confused	the VMT referencing tool
1421	So we're technically done with all of it right?			
1422		this is ours		big square: (2n-1)^2 4 corners: n(n+1)/2*4 (2n-1)^2 - n(n+1)/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			

5. 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:
  a) Objectivity
  b) Reliability
  c) Generalizability
  - Etc.

a) Objectivity

- The data is automatically logged
- No selective perspective (camera angles, lighting, choice of heard or remembered)
- No interpretive transcription
- Logs include all relevant details of interaction
- Replayer allows extremely detailed analysis: like a digital video with timecode, slow-mo, pause, next/previous action

Objectivity

- The VMT Replayer displays everything that was shared by the participants – *exactly the group unit of analysis*
- Everything that was shared went thru server
- Log includes every action with exact time
- Replayer is created exactly like original displays were created
- Analyst accesses exactly what would have been available to a "fly on the wall" – but with ability to proceed as needed and repeat

b) Reliability

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

c) 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

The power of this science

- Analysis of group interaction (group cognition)
- Can show HOW (not just quantitatively THAT)
- The group can achieve cognitive accomplishments that none of the individual members of the group can
- (the group accomplishment may not even be completely understood by individuals)

Vygotsky's zone of development

- Analysis of small-group interaction can EXPLAIN the ZpD by showing how a group-level "train of thought" is built by contributions of many individuals
- And by latent relationships implicit in the semantic relationships — never present in any individual mind. The meanings are human in origin, design and nature, but not necessarily configured by any individual the way they are by the group — although there is subsequently the possibility for individuals to take them up as their own resources for individual cognition

Other theories

- Behaviorism and cognitivism by definition associate all cognition with individual minds
- Post-cognitivist theories emphasize the involvement of artifacts, other people, the context and socio-cultural forces in cognition
- E.g., distributed cognition (Hutchins), situated action (Suchman), situated learning (Lave), activity theory (Engeström), ethnomethodology (Garfinkel), actor-network-theory (Latour)

Other theories

- E.g., Hutchins (2000, p. 176) says: “Cognitive processes may be distributed across the members of a social group.”
- But he analyzes socio-technical systems and the cognitive role of highly developed artifacts (airplane cockpits, ship navigation tools)
- These artifacts have encapsulated past cultural knowledge (community cognition)
- But not the cognitive meaning making of the group itself

Other Theories

- Provide some nice studies of the pivotal role of small groups, but do not account for this theoretically
- They are based on either a psychological view of individuals or a sociological view of rules, etc. at the community level
- None of them have a foundational conception of small groups as a distinct level
- They confuse talk of group level and social level
- They lack an account of the relationships between individual, group and community

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 cognitive 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-day-long sessions
- Dynamic geometry (multi-user GeoGebra)
- Use with math teacher professional development
- Encourage collaborators to use and study VMT
- Contribute to a science of virtual group cognition

For Further Information

- Slides: http://GerryStahl.net/pub/edschool2009ppt.pdf
- Website: http://GerryStahl.net
- Email: Gerry.Stahl@drexel.edu
- *Group Cognition* (2006, MIT Press)
- *Studying Virtual Math Teams* (2009, Springer)