

Troubles of Understanding in Virtual Math Teams

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ABSTRACT**Troubles of Understanding in Virtual Math Teams**

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When groups engage in math problem solving in an online environment like the VMT (Virtual Math Teams) service, they can face significant challenges from troubles of individual and group understanding that emerge in their problem-solving process. We are interested in how shared understanding is interactionally constructed and accomplished in a collectivity engaged in mathematical reasoning and problem solving in the VMT environment when understanding troubles or differences of understanding between members arise. From our analyses of chat interactions of such collectivities, we have come to see that it is by attending to, managing, and resolving troubles of understanding that shared understanding is achieved. This dissertation investigates the practices by which participants introduce and present such troubles of understanding and how these problems are managed and dealt with by members of the collectivity. In particular, by analyzing the episodes of interaction of VMT groups, we document the interactional methods employed by participants to initiate and constitute their troubles as such and we explicate the procedures involved by which those troubles are addressed.

CHAPTER 1. INTRODUCTION

1.1. Motivation and Objectives

Information behavior

Human information behavior (HIB), rather broadly and vaguely defined as “the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking, and information use” (Wilson, 2000), has been one of the most studied topics in the research community of information science. A large number of researches have been carried out studying “how people need, seek, give, and use information in different contexts” (Pettigrew et al, 2001). As advocated by the Sense-Making meta-theory, there is no universal pattern of information behavior that exists across time and space (Dervin, 1983b). The emergence of social computing has posed a unique context for information practices and demands closer examination in order to entail us a better understanding of the phenomenon situated in this particular context. This also calls for a different set of research methods to approach the questions under investigation.

The connectivity among people brought by social computing provides a context for studying information practices which is distinct from the traditional settings. Social computing applications connect people and people interact with each other in groups, either accomplishing a certain work related task, learning, or socializing. Many of the tasks nowadays require people to be able to collaborate and work together, either physically or virtually via distributed networks. Most studies on information behavior tend to focus on *individuals* and examine how individuals perform certain information seeking tasks. In other words, information behavior is investigated by looking at how *individuals* need, seek, and use information. Recently there are emerging studies on *collaborative information behavior*, where researchers examine information behaviors within different collaborative, mostly, work settings. In those studies, individuals are still the focus and the context of collaborative setting plays as a background for individuals’ information behavior. The research methods are not fundamentally different from those applied in traditional studies. It is no doubt that individuals are components of a group. Even collaborating in a group, individuals still inevitably perform their own tasks, have their own thinking, etc. Individuals are indispensable parts of a group. However, theories and research on collaboration and groups have explicated that a group could achieve more than the total of individuals within and what is produced by the group is not reducible to individuals (Bereiter, 2002; Stahl, 2006b).

Many information behavior studies tend to focus on how a certain population group look for information for *structured tasks*, imposed either in experimental or naturalistic setting. In such setting, usually a certain group of people are users of some information systems and researchers study how they interact with the information system in order to find information to complete the imposed structured information seeking task. Among those studies, many of them have the purpose of improving operations in libraries or systems of information resources. As many of us may have recognized, information seeking is always situated in a broader context of practices and people do not merely seek

information but seek information for certain purposes such as in order to accomplish certain things, be it learning, problem solving, or entertaining, etc. The *broader practices* such as learning or problem solving are not merely information searching but much more complex. It can entail us better understanding of information behavior and have more practical implications if we look at it from the broader practices people are engaged in. The emerging online communities enabled by social computing are usually formed by people who share similar interest. There are communities of practice, communities of interest, and learning or knowledge building communities in the online environment. In order to understand those communities' information behavior, it is necessary to examine participants' practices, in other words, what they do and how they actually do it, from a broader context such as learning or problem solving.

When a group of students get together and discuss on solving a math problem in an online environment such as at the Virtual Math Teams (see the description of the project later in this section), we observed that participants actively engage in various information practices, such as identifying what information they need in order to solve the problem, looking for information using various resources, making sense of the discovered information together, and applying it to the problem. All these activities are done together in the group, and in many cases, collaboratively. Analyzing how participants constitute their information problem and how they address the problem using various available resources can entail us a better understanding of some fundamental problems that information science community is concerned about such as how information needs are constructed, how people do information seeking, how relevance of information is assessed, and information is used for a particular situation. Some of these issues have remained challenging and difficult to study when treated as private experience and something taking place in individuals' heads. But a group setting such as VMT provides opportunities to examine social information behaviors and potential to approach those challenging research problems from a different angle, that is, those processes are recorded and made publicly observable thus accountable. For example, in traditional information behavior studies, the processes of information use are left in a "black box" because of conceptual and methodological difficulties. The transcript data recorded from VMT sessions have demonstrated the possibility of opening up the "black box" because the processes are made publicly available for examination. Examining participants' lived experiences can also contribute to informing the design of information resources and particularly, the design of digital libraries to support learners' particular needs in CSCL environments.

Computer-Supported Collaborative Learning (CSCL)

Computer-supported collaborative learning (CSCL) is an emerging branch of the learning sciences concerned with studying how people can learn together with the help of computers (Stahl, Koschmann, & Suthers, 2006). It is one of the most prominent exemplifications of social computing applications that makes use of computer technologies to bring people together and learn collaboratively. It proposes the development of software environments that bring learners together and stresses the productive social interaction among students. It promotes that students learn by "expressing their questions, pursuing lines of inquiry together, teaching each other and seeing how others are learning". One example of a CSCL environment is the Knowledge

Forum developed by Carl Bereiter and Marlene Scardamalia (Scardamalia & Bereiter, 1996) based on the theory of knowledge building. It is believed that effective learning can be achieved by students engaging in a discourse and refining their ideas by asking questions, providing explanations, and formulating theories. Embracing the social constructivist and situated views of learning (Piaget, 1932; Vygotsky, 1930/1978; Lave & Wenger, 1991; Suchman, 1987), CSCL locates learning in meaning negotiation carried out in the social world rather than in individuals' minds – therefore a process available for inspection and collaboration is conceptualized as a process of constructing shared meaning. The central concern of CSCL as a field of study has been recognized as “meaning and the practices of meaning-making in the context of joint activity, and the ways in which these practices are mediated through designed artifacts” (Koschmann, 2002b). This is echoed by the conceptualization of such practices as *intersubjective learning* (Suthers, 2005) or *group cognition* (Stahl, 2006). Although this has been proposed as central to the research agenda of CSCL research, detailed interactional studies that take the collectivity as the unit of analysis and investigate the practices have remained challenging for the field.

If we consider a goal of learning is to foster deeper understanding, then one of the most apparent benefits of collaborative learning perhaps is from how participants could construct and develop shared understanding through interactions among them. When one participant has trouble understanding some math concept or proposed idea, he may pose a question eliciting explanation and explanation may be produced by a more competent member (in this local situated context). Some shared understanding regarding the matter of concern emerges as a result of this question-response process. This coincides with Vygotsky's theory of the “zone of proximal development” that the less competent participant achieves the understanding with the help, or scaffolding, of the more competent co-participant. In other cases, differences of understanding regarding a mathematical matter may arise between participants that they attend to, for example, by engaging in argumentations. A better understanding may be achieved through resolving such differences or conflicts. This aligns with Piaget's perspective on learning, described as socio-cognitive conflict theory (Piaget, 1932). In order for us to come to a better understanding of collaboration and learning, examining how participants attend to their troubles of understanding and resolve them together as a group is central as part of the important effort of studying meaning-making practices of participants.

The Virtual Math Teams Project

The *Virtual Math Teams* (VMT) project is an NSF-funded research project where researchers at the College of Information Science and Technology (*the Information School*) and the Math Forum (both at Drexel University) investigate the innovative use of online collaborative environments to support effective K-12 mathematics discourse¹. The Math Forum is an established organization that provides online educational resources for mathematics, including math digital libraries and mentoring services². Among the services, one of the most popular is the *Problem of the Week*, where one math problem (either geometry or algebra) is posted every week for which students submit their solutions. The Math Forum staff will read the submissions and post feedbacks online

¹ <http://mathforum.org/vmt/>

² <http://mathforum.org>

along with featured solutions. The *Virtual Math Teams* project has been devoted to designing and deploying a service as an extension to the current *Problem of the Week* service at the Math Forum, which aims to bring students across the nation and the world together to talk about math in online chat environments collaboratively. One of the main goals of the VMT project is to design an online collaborative environment to support students to learn mathematics together and build a community of people who are interested in math (Stahl, 2006b) to promote knowledge building through math discourse. This goal is being approached through a design-based research (DBR) (Brown, 1992; Collins, 1992; Design-based Research Collective, 2003) effort that involves starting with something very simple and designing the environment and service through an iterative process. The DBR approach emerged as a strategy to address the complexities of investigating how designed artifacts contribute to learning in naturalistic settings. It involves progressive improvement of instructional and technological interventions and the theory informing their design. Following a DBR approach, another major goal of the project, which is closely related to our design goal, is to explore the nature of collaborative learning and small-group interactions that take place in chats in the VMT environment so that theories about small-group interactions can be evolved to inform the design.

In order to design an online collaborative environment that could support learners in accomplishing their task in the environment and also scaffold them to lead to effective learning and collaboration, we need to understand how the systems we provide are used by students and how collaboration and learning are being achieved and mediated by artifacts and affordances provided in such environments. This requires a closer look at the participants' lived experiences of how they go about doing collaborating and math problem solving. As researchers at the VMT project, we study how small groups of students do mathematics collaboratively in online chat environments (Stahl, 2006a). In particular, we are interested in understanding the social practices that participants develop to do so such as making a math proposal, defining a math problem, requesting for an explanation, presenting a different opinion, producing an explanation, and so on. Among these practices participants develop when engaged in doing math problem solving together, one dimension particularly of interest to us is related to how they do "understanding work" when facing troubles or problems of understanding. One practice that probably is familiar to all of us is asking a question as a way of introducing troubles of understanding. This seemingly simple, straightforward practice however is intricately complex, as revealed in our study that will be discussed later, as such practice, among others, is responsive to the social norms, the chat medium, the institutional setting, the shared experiences of the group session, and the resources available to the participants in the environment. For both the Math Forum and the VMT project, it is of critical importance to develop a solid understanding of how participants in a group organize themselves to attend to troubles of understanding when they are engaged in mathematical reasoning and problem solving, as part of the effort of exploring the nature of collaborative learning in such online environments as well as informing the design of the service, including the technological environments and mentoring services, to sustain and promote the practices.

1.2. Problem Statement and Research Questions

Three middle school students with handle name NISH, JAS, and EUR from the virtual math teams are interacting in the VMT Chat environment working on a math problem – *the grid world*. The problem is presented to the group as follows:

Pretend you live in a world where you can only travel on the lines of the grid. You can't cut across a block on the diagonal, for instance. Your group has gotten together to figure out the math of this place. For example, what is a math question you might ask that involves those two points?

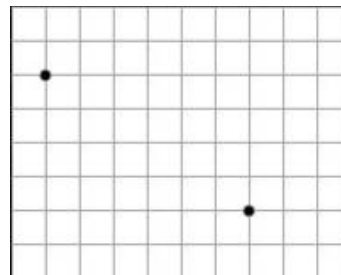


Figure 1.2.1: The grid world

This is the third session of the four in total this virtual team have been participating. In the previous sessions, the participants have defined some questions in this grid world. Now, they are working on one of the questions, which is: *How many shortest paths are there along the grid between pairs of points? Is there a formula?* Prior to the part shown in excerpt 1, it was proposed by one of the participants that they should draw the paths between two points and count them, “then we may be able to find out a formula for the number of possibilities”. Then NISH proposes the use of permutations and tree diagrams in line 150 (excerpt 1.1). From the traditional information behavior study’s point of view, the phenomena of interest may conclude right here: the needed “information” (permutations in this case) is provided by one of the members – we as researchers know from our math knowledge that this is the right concept to use to solve the problem – and they can simply use it and the problem will be solved. However we see in the data that it is not the case. The two participants, JAS and EUR, seem to have troubles understanding *how* the offered math concept could be used for their problem at hand: JAS makes a request for demonstration (line 151) whereas EUR makes a self report on his trouble (line 155), followed by a question that seemingly elicits explanation from the presenter NISH on how “permutation” can be used to solve the problem. Although EUR’s later post at 159 shows that his previous “question” is rather probelmatizing the idea of using permutation to solve the problem than seeking explanation, it nevertheless does the work of initiating the trouble with the introduced idea and echoes with JAS’s trouble. NISH subsequently produces an explanation with reference to the diagram on the shared whiteboard to demonstrate how the concept can be applied to the problem situation. It is through the interactions participants engage in doing that the trouble with “permutation” is introduced and its meaning is constructed. During the meaning-making process, questions are used to make request for demonstration, to challenge the idea, reports are

made concerning troubles of understanding, and explanation is produced using both text post and drawings on the shared whiteboard. The record of the interactions provides us opportunity to look into the processes of participants' meaning-making. In particular, analysis of their interactions entails us better understanding on the social practices participants develop to get such work done interactionally.

150 NISH well the way i know how to find number of possibilities is
through permutations and tree diagrams
151 JAS can you show us by drawing on the board?
... *(a few lines omitted here)*
155 EUR i dunno bout the permutation
156 EUR how do u use it to solve this
157 JAS i dun either
158 NISH the first choice starting at A is either traveling east or south
159 EUR permutationis a limited factorial

Excerpt 1.2.1: How do we use permutations?

When participants are working together on solving a math problem in the VMT environment, troubles of understanding such as problems or differences in understanding often arise. Resolving such troubles becomes a practical issue for the group to deal with and sometimes can be a challenge. Troubles of understanding could be caused by knowledge deficit of participants regarding some math concepts introduced, like we see in our previous example JAS has with applying the concept “permutations” to the problem, or differences between the understanding individual participants hold, such as EUR considers “permutation” as “a limited factorial” therefore challenges that it can be applied to solving their problem as proposed by NISH. When facing troubles of understanding, how to initiate the trouble and introduce it as relevant to the ongoing interaction in the group is a practical matter for participants. In some cases, a rather straightforward information question is posed to elicit information on the trouble source. But often, such questions seem to be designed artfully in ways that not only allow them to elicit information but do other work as well. In the following example (excerpt 1.2), a question is posed by SUP eliciting information on “edglenghts”, followed by a candidate answer in the next post. A definition of “edgelenhth” is provided by AVR in the subsequent line, which is received by SUP as an adequate answer to his question, who gives an assessment “ok”. The process of question-answer is rather straightforward and does not appear to be problematic.

SUP what does itmeans by edglenghts?
SUP jone of the 3 sides?
AVR edgelenhth means length of a side
SUP ok
Excerpt 1.2.2

In another example (excerpt 1.3), however, we see a question is posed with some setup: “*hope this doesnt sound too stupid, but wuts a summation*” by NISH (emphasis added). What work does the question designed in this particular way do other than eliciting information? The question is taken up by both recipients respectively who each

produce an answer of a very different nature. The answer from participant with handle name 137 appears to be a definition of “summation”. What JAS provides, however, is a link to a wikipedia article, which presumably is relevant to the question and it contains information that is considered as useful to address the trouble introduced in the question. In our later analysis, we unpack this sequence of interaction more to explore how a question like this “brackets” the peer relationship issue, i.e. the questioner’s competency, to put it aside so that it will not be attended. It not only elicits information but also does the work of sending out the signal that one wants to participate and be part of the group. The response provided to the question also is consequential for their interaction in that certain responses could do the work of engaging the questioner while others tend to shut down the questioner by treating him as not an equally competent member of the group.

NISH hope this doesnt sound too stupid, but wuts a summation
 137 The sum of all terms from a to b
 JAS http://en.wikipedia.org/wiki/Sigma_notation
 Excerpt 1.2.3

The observations of how participants deal with troubles of understanding when they do math reasoning and problem solving together in the online environments leave a question to us as educators and analysts to wonder about: how is a question designed and constructed as a way of introducing troubles of understanding. This leads to a follow-up question, which is whether the way a question is designed and presented has to do with how it is taken up by the group in providing an answer. We have also noticed that when facing troubles of understanding, participants may not necessarily choose to ask a question. There might be various reasons for this. One is that asking a question also requires certain competency – one has to know enough to be able to formulate an adequate question to introduce the trouble. Another possible reason is that being in a peer relationship, there might be concerns of “face” issues that asking a question may risk being considered as lack of competency. Instead of asking a question, they may make a self report regarding their problematic understanding status or in the example we see next, a self report regarding the participant’s own math competency (excerpt 1.2.4). This report by Nish is taken up by moderator of the session who clearly sees it as a signal of trouble that Nish has. He directs a question to Nish that elicits from him a report of his trouble in the subsequent post more than 30 seconds later. Nish’s trouble of understanding is constructed by his answer to the moderator’s elicitation. In our later analysis, we go into details in analyzing this sequence of interaction to pull out an interactional method – making a report – that is commonly used by participants to introduce their troubles. From there we also show how a question is reformulated based on response received as well as how a subsequent response is co-constructive as a collaborative effort of multiple participants.

Line#	Handle	Chat posting	Time
126	Nish	just to clarify sumthing, i am not overwhelmingly good at math as u guys seem to be, so it may take me more time than u guys to understand sumthing..	06.45.11
127	Moderator	can you tell us what's puzzling you?	06.45.44
128	Jason	are we allowed to post images on the wiki? I could just download TeX real quick and get the summation notation in a small graphic	06.46.07
129	Nish	the derivation of the number of squares	06.46.12

Excerpt 1.2.4

Troubles of understanding can arise regarding ideas such as a proposal to approach the problem or some work presented that has been done by a member. Examining the practices of participants engaging in attending such troubles allows us to look into the processes of meaning-making, collaboration, and learning. The interactions made available in the data provide avenues for us to study information behaviors in small groups, in particular, how “information needs” are (co) constructed and how “information” is made sense of and used to their problem at hand. The dissertation is set to investigate the interactional methods participants use to attend their troubles of understanding and the procedures involved. The dissertation is structured around two related research questions:

RQ1: How are troubles of understanding with respect to mathematical concepts, reasoning procedures or problem solving introduced and made relevant to the ongoing interaction in the group?

RQ2: How are the introduced troubles dealt with in the group and how is shared understanding co-constructed?

CHAPTER 2. THEORETICAL FOUNDATIONS

2.1. Current models and theories on information behavior

The issues related to *troubles of understanding* are not ever foreign to the field of information science, although they tend to be labeled differently. In fact, they have always been of the interest to the field, and more particularly, among the central concerns of the line of inquiry on human information behavior (HIB), “the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking, and information use” (Wilson, 2000). *Human information behavior* (HIB) has remained one of the central research topics that have drawn significant attention from researchers in the field of information science. In their landmark ARIST (*Annual Review of Information Science and Technology*) review, Dervin and Nilan (1986) observed the **user-centered paradigm** shift from a system-centered approach, characterized by “its focus on constructive, active users, subjective information, situationality, holistic views of experience, internal cognition, systematic individuality, and qualitative research” (Pettigrew et al, 2001). A user-centered approach to studying information behavior has pervaded the literature since then. There has been the Conference of Information Seeking in Context since 1996 dedicated to this approach. In 1999, the American Society for Information Science (ASIS) established the special interest group of “information needs, seeking, and use” (SIGUSE). Pettigrew, Fidel and Bruce (2001) in their review of conceptual frameworks in information behavior provide a definition as “how people need, seek, give, and use information in different contexts”. Accordingly to this definition, the scope of study encompasses a wide range. Even though active information seeking behavior has assumed a weighted position in the literature, it is only one part of the wide range of “behaviors”. For example, information behavior also encompasses a range of practices including non-active and non-purposeful information seeking such as serendipitous information behavior, i.e. encountering information unexpectedly (Erdelrez, 1997) or less directed as “information gathering” (Krikelas, 1983). It also includes information acquiring, managing, generating (Ingwersen & Jarvelin, 2005), and many others.

Researches on human information behavior can be traced back to the earlier stage of studying **information needs** and uses, which has emerged with the user-centered paradigm shift. What initiates seeking, which is considered as the “needs” for information, has received significant attention. Accompanying the paradigm shift is the prevalence of the cognitive approach for framing research problems and carrying out studies. Some of the prominent examples of scholarship that represent this line of research include Taylor’s question negotiation (1968) and Belkin’s ASK hypothesis (1982), which are of particular relevance to our research questions on troubles of understanding. Taylor derives a model of the information-seeking process in libraries. The primary assumption underlying this construct is that an information need is “something distinct and traceable” (Taylor, 1962, p.392). The model consists of three major components:

- 1) Four stage model for the expressions of individuals’ information needs. “An inquiry is merely a micro-event in a shifting non-linear adaptive mechanism”

(Taylor, 1968, p.179). This mechanism involves transitions between several stages in the *mind* of the inquirer:

- a. the actual, but unexpressed need for information – the *visceral* need
 - b. the conscious, within-brain description of the need – the *conscious* need
 - c. the formal statement of the need – the *formalized* need
 - d. the question as presented to the information system – the *compromised* need
- 2) process model for prenegotiation decisions made by the inquirer
 - 3) five filters through which a question passes during negotiation

Taylor's model is based upon limited empirical evidence by conducting a small number of open-ended and unstructured interviews with special librarians. The negotiation of questions is placed with an intermediary within a larger context of information seeking behavior.

There has been a good amount of endeavors dedicated to understand the concept of "information needs" and what may motivate people to look for information to satisfy such needs. For example, some researchers believe that when people realize there is a knowledge deficiency, that is, their current knowledge is not adequate to solve an *anomaly in the state of knowledge* (ASK) (Belkin, 1980), to solve a problem or *bridge a gap in understanding* (Dervin, 1983a; Itoga, 1992; Dervin & Nilan, 1986), they are in need of certain information. Along the same line, Kuhlthau (1993) sees information seeking as caused by "uncertainty due to a lack of understanding, a gap in meaning, or a limited construct". And most information retrieval (IR) systems are operated on a "best-match" principle, which returns the texts that are considered best matches to what is expressed and specified by the user as a representation of information needs. However, such underlying assumption that what a user specifies as a query is an ideal representation of his/her information needs is questionable and unwarranted. This component of an IR system has been questioned by many researchers and thus brought up another central issue of document relevance. With an analysis of the fundamental problem of information science as "the effective communication of desired information between human generator and human user", Belkin proposed his famous hypothesis of the *anomalous states of knowledge* (ASK) to characterize that information needs are not in principle precisely specifiable (Belkin, 1980). By anomaly, Belkin means that the user's state of knowledge with respect to a topic is in some way inadequate with respect to the person's ability to achieve some goal (later generalized as the ability to resolve a problematic situation) (Belkin, Seeger, & Wersig, 1983). An information need arises from a recognized anomaly in the user's state of knowledge concerning a certain situation and in general the user is unable to articulate and specify what is needed to resolve the anomaly. ASK has obvious relationships to Taylor's "unconscious need". It also has some connections with Wersig's (1985) "problematic situation" and Dervin's (1983b) "gaps".

ASK hypothesis tries to provide an explicitly cognitive explanation of the general phenomenon. Belkin believes that it is possible to elicit problem statements from users and the representation of information needs can be derived from carefully designing information systems (Belkin, 1990). One obstacle of implementing such a theory in a real

system may lie in the difficulty of testing such a hypothesis and to derive a set of operational guidelines for system design. Such difficulty may be attributed to the underlying cognitive viewpoint, which assumes that states of knowledge are something residing in an individual's head while it is hard, if not impossible, to get into a person's mind and find out what may be going on. Within much of the information behavior, particularly information seeking literature, theorists suggest that information needs arise when an individual finds herself/himself in a problem situation where she or he can no longer manage with the current knowledge possessed. Those theories or hypotheses may help explaining how "information needs" arise but they are not particularly insightful in entailing us understanding of how an information need evolves from *unspecifiable* to structured and articulated, especially in a collaborative group setting. In the context of small group setting like VMT teams, participants engage in mathematical problem solving together, where interactions are mediated through the online environments. Actions are made available and visible to each other and at the same time to us as analysts. This provides a unique venue for studying how participants present their problematic situation to others, for example, how a competent information seeking question is constructed and negotiated through the group interaction and how a response such as an explanation is produced to address the trouble initiated by the question.

2.1.1. Models on information behavior

Researchers have developed theories and models on user's information seeking and information retrieval, among which some have been highly influential. Many of the existing models of information behavior are particularly focusing on information seeking behavior. Models typically deal with more specific problems than theories do, though they are often defined in relation to theories. Simon and Burstein (1985, p.53) call models "minitheories". Though a model tries to represent and organize a complex process, it usually simplifies a phenomenon and depicts key elements for researchers to select explanatory factors to investigate (Johanson, 1997). As Wilson (1999a, p.250) points out:

A model may be described as a framework for thinking about a problem and may evolve into a statement of the relationships among theoretical propositions. Most models in the general field of information behaviour are of the former variety: they are statements, often in the form of diagrams, that attempt to describe an information-seeking activity, the causes and consequences of that activity, or the relationships among stages in information-seeking behaviour.

There are quite a few models on information behavior that have been developed in the past two decades or so. Some are more general, intending to capture a more complete spectrum of human information behavior, whereas some tend to focus on specific aspects of the whole range of activities, e.g. information seeking or information searching.³ This section will review a few select general models. Wilson's model of 1981 (see *Figure 2.1.1.1*) is oriented towards a more general picture of the activities involved and their

³ Wilson depicted the relations of these areas in his nested model (Wilson, 1997), where "information behavior" is the broadest area, which includes "information seeking" as a subset, and "information searching" is nested within the subset of "information seeking".

relationship, which he later clarified as to present a way of thinking of the field of “user studies”. Its aim is “not to ‘model’ information-seeking behavior but to draw attention to the interrelationships among concepts used in the field” (Wilson, 2006). He points out information-seeking behavior may take different forms: the user may demand upon formal systems that are customarily defined as information systems (such as libraries or online services), or other systems that mainly serve non-information function. It is noticeable that in this model, Wilson also recognized *human interaction* can be another aspect of information seeking: the user may seek information from other people, rather than systems, which is illustrated in the model as “*information exchange*”. Wilson uses “exchange” purposefully to draw attention to the element of reciprocity, which is recognized by sociologists as a fundamental aspect of human interaction.

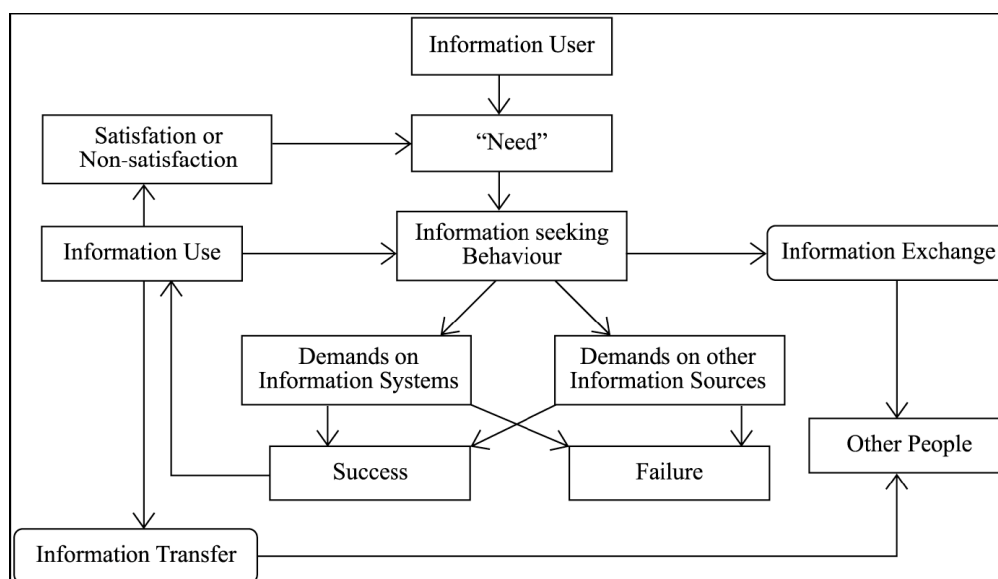


Figure 2.1.1.1: A model of information behavior

(Adapted from Wilson 1999: *Models in Information Behaviour Research*, Journal of Documentation, 55(3))

Among the different activities of human information behavior as depicted in this model, some have attracted more attention from the field such as information “need” and information seeking behavior particularly of using formal information systems, whereas some have drawn relatively less interest or are not well studied or neglected. For example, “information exchange” as defined here has not been examined closely by information scientist even though it is a phenomenon of potential interest to the field. Especially with the emergence of social computing, online communities have been growing rapidly, where the activities of seeking information from and sharing information within the community are prominent. It has been recognized that people often have strong preference for getting information from interpersonal and informal communication since very early time of this field (e.g. Glass & Norwood, 1959) and more researches (Pettigrew, 1999; Xu et al, 2006) have been put into studying people’s information seeking from others. The development of social computing technologies and emerging applications provides more options for an information user to satisfy their “needs” other than seeking from formal information systems and face-to-face interpersonal interactions. How this is shaping people’s information seeking is brought up to the research agenda for the community. In such interactions between people, information is not simply

exchanged as may be conceived in interaction between a user and formal information system but constructed and made sense of in and through such interpersonal interactions. As Wilson recognized in his recent review of the 60 years of information research on *user studies and information needs* on the Journal of Documentation (Wilson, 2006), **information use** is one of the most neglected areas. This is also echoed by Savolainen (Savolainen, 2006) who took a major step in exploring the conceptual issues of information use by reviewing the ideas of Dervin's Sense-Making methodology. Those issues of information use have posed a challenge for library and information studies both conceptually and empirically. As a result, the processes of information use have been left in a "black box". Attention has been chiefly paid to more tangible behavioral traces such as the frequency of certain library resource use within a fixed period of time. Much remains to be discovered for the actual use of information. More work is needed to analyze how meaning of information is socially constructed through interactions, which requires a closer look at the meaning making process. This calls for descriptive and explorative studies on the practices of what people actually do in making use of the discovered information.

Wilson's 1982 model (Figure 2.1.1.2) draws upon constructs from psychology and proposes that a) information need is a secondary need that arises out of needs of a more primary kind; and b) seeking information to satisfy the need may encounter barriers of various kinds (i.e. personal, role-related, and environmental). This model embodies some hypothesis for test such as how personal traits may affect information seeking. It nevertheless points out the context of information need as an important construct and brings to awareness the existence of factors that may hinder information seeking. The revised 1996 model (Figure 2.1.1.3) draws upon more theories including social learning theory and recognizes that the factors not necessarily hinder but rather intervene, including their supportive effects, information seeking behavior of users. The expansion and inclusion of more theoretical models and intervening variables make it a richer source of hypothesis and future research. Our study will contribute to understanding information seeking behavior in a small group and online environment context from an interactional perspective by looking into the practices of what participants do when engaged in collaborative problem solving. Examining the processes allows us to see how their troubles of understanding are initiated and constituted through interactions. Instead of considering some predefined variables as factors intervening their actions that presumes understandings of the phenomenon which yet to be understood, we try to take participants' stance and examine the phenomenon from the angle of how they orient themselves to attend such "needs" arising from their problematic situation. The VMT data allows us to do so through looking into the social practices of the participants to see how social order is constructed and how "information" is made sense of, rather than imposing hypotheses of what may be taking place.

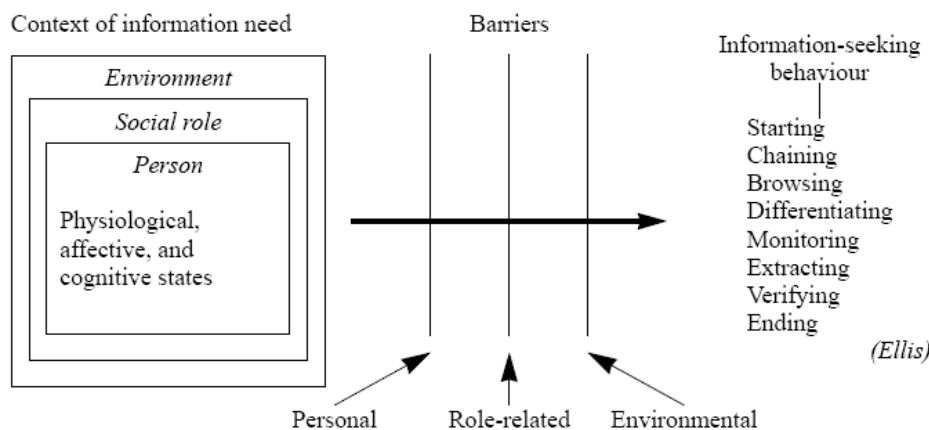


Figure 2.1.1.2: Wilson 1981 model of information seeking behavior

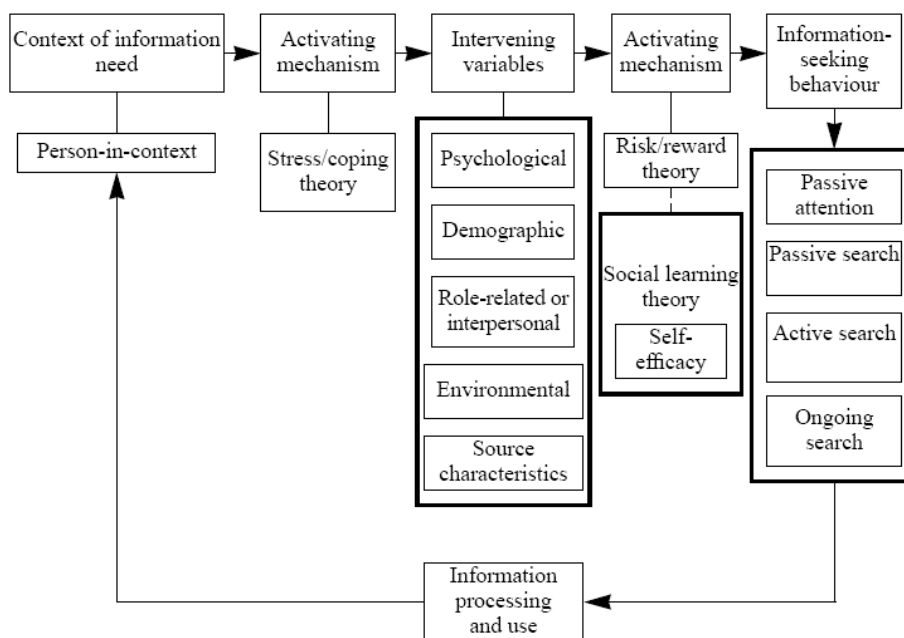


Figure 2.1.1.3: Wilson 1996 Information Behavior Model

Krikelas (1983) examined the elements of user studies and tried to present them as unified concepts within a model of information-seeking behavior in response to recognizing the lack of a single theory of information use that renders the comparison of studies in the field difficult. In presenting his influential model, Krikelas discussed the definitions of information-seeking behavior, and concepts of information needs, information gathering, information giving, and user's preference for information source. Information-seeking behavior here is defined as any activity an individual is taking to identify a message that satisfies a perceived need. In this context, information is viewed as a stimulus that reduces uncertainty and information need as articulated, conscious need rising from someone's perception that "the current state of possessed knowledge is less than that needed to deal with some issue (or problem)" (ibid, 7).

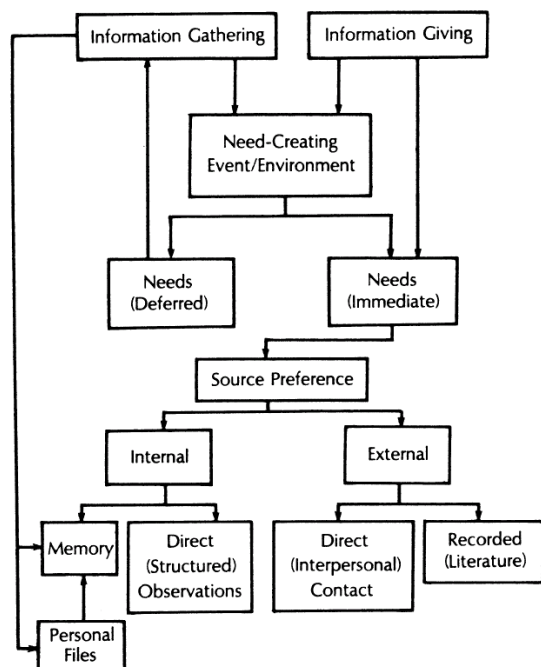


Figure 2.1.1.4: Krikelas's Information-Seeking Behavior Model
 - Adapted from Krikelas, James (1983) Information seeking behavior: Patterns and concepts. *Drexel Library Quarterly*, 19, 5-20.)

This model recognized the less directed and more causal information gathering, which responds to “deferred need”. Krikelas also called the attention to information giving as one construct of information behavior, even though information giving here is relatively narrowly defined as disseminating “messages” in various forms such as written, graphic, verbal, or visual. This model also pointed out that people may have preference for use of source to get information. Questions need to be addressed is what sources are selected for information and why. Krikelas’s model has been influential in the field of information behavior and remains one of the most widely cited. It is one of the few early models that aim to be general and applicable to various contexts of information behavior. And one appealing feature of this model is its simplicity: a few straightforward constructs with one-way relations between them. As articulated clearly by Krikelas, “the ultimate value of this (information-seeking behavior model incorporating the concepts described), or any other model, lies in its utility in the design and analysis of future empirical studies” (ibid, p17). Some of the concepts depicted in this model are particularly interesting for us to examine in the online community of the Virtual Math Teams. For example, the sources identified here provide guidance to look at the different sources participants use to demand information systematically and some hard distinctions made between sources may need revisit. Analyzing from our data from interactions taking place in such naturalistic setting could reveal the preference participants may have in choosing information sources. And closer analysis could help us understand why some sources are chosen over others. Also, information giving, which has remained a relatively less studied aspect, seems to be quite commonly observed in the virtual teams and further examination is needed to understand how participants provide information in their chat, on shared whiteboard, in wiki, etc, for various purposes.

Another one of the most cited models is the **Information Search Process (ISP)** developed by Kuhlthau’s landmark study, which attempts to capture the whole experience of the information seeker by taking into account the information seeker’s cognitive, affective, and physical experiences at different stages of the process. Based on

George Kelly's personal construct theory, the Information Search Process depicts information seeking as a process of construction. Kuhlthau (1991, 1993) conducted a series of longitudinal studies that investigated students' information seeking in libraries on completing assigned tasks that covered the span from their high school to college. Students have a complex task that has a discrete beginning and ending, and requires construction and learning to be accomplished. The first study is in small scale and naturalistic settings, which is followed by two longitudinal studies and two quantitative studies. Kuhlthau found common patterns in users' experience of information seeking in libraries. Users usually experience certain feelings, have certain thoughts, and take certain actions at particular stage of the information seeking process. These stages are differentiated into *Initiation, Selection, Exploration, Formulation, Collection, and Presentation*, where each stage represents the primary task at each point and thoughts, feelings, and actions commonly experienced were identified in each stage of the process.

The ISP model also proposes a conceptual premise as an "uncertainty principle" for library and information services and systems. It states that uncertainty is a cognitive state that commonly causes affective symptoms of anxiety and lack of confidence. Uncertainty may be due to "a lack of understanding, a gap in meaning, or a limited construct" and it initiates the process of information seeking. Kuhlthau also introduced the concept of a zone of intervention drawn from Vygotsky's zone of proximal development for diagnosing a user's need for assistance and support. The zone of intervention is defined as the area in which "a user can do with guidance and assistance what he or she cannot do alone or can do only with difficulty". Taken together, the stages of the ISP, uncertainty principle, and concept of a zone of intervention proposes a conceptual framework for understanding information seeking as a process of construction from the user's perspective (Kuhlthau, 2004). The conceptual framework is based on the experience and behavior of people involved in extensive research projects that need to be accomplished in a prescribed period of time.

Bates' berry-picking model also tends to focus on users' information seeking and try to provide suggestions to the interface design of information retrieval systems. Bates (1989) argued that real information searching does not always work in the one query/one use way that has been assumed. She proposed a berry picking model and described a variety of design features for online systems. According to Bates, real-life queries change and evolve during the course of searching.

At each stage, with each different conception of the query, the user may identify useful information and references. In other words, the query is satisfied not by a single final retrieved set, but a series of selections of individual references and bits of information at each stage of the ever-modifying search. (1989, p. 410)

Bates called such bit-at-a-time retrieval berry picking, by analogy with picking berries in the forest.

These models are oriented towards how information users interact with formal information systems to find the desired information, which is usually predefined and structured. Some models try to depict the factors that motivate, hinder, or affect (e.g. the choice of information resources) information seeking actions. For example, Johnson's model in Cancer-related information seeking identified four antecedent factors under two categories (background and personal relevance factors) and information carrier factors that account for information seeking actions. Background factors: demographics and

direct experience; personal relevance factors: salience and beliefs (Johnson, 1997). Studies also have been conducted to explore how the nature of tasks may affect information behavior in the context of problem solving. For example, Bystrom and Jarvelin explored the relation between task complexity and information seeking and use. The findings of their study indicated systematic and logical relationships among task complexity, types of information (in this context, problem information, domain information, and problem-solving information), information channels, and sources.

Many studies in information science examine information behavior in *particular contexts*. They usually focus on certain groups of population such as academic researchers, professionals, etc. and try to associate those independent variables, which are usually used to characterize the groups, the information seeking tasks, and the information systems in use, with what is set to be investigated, e.g. the observed behavior of users. These studies seem to spread out on all sorts of peculiar settings and they are hard to weld together to provide a general picture of how information practices are like across these contexts. In other words, it is questionable how generalizable those conclusions being drawn in the studies are. Would they still hold true if the same study was taken to a different setting? We believe that people's information practices share something in common across different contexts that we as researchers could grip onto. And how to grasp what is in common is to look into the *practices* of what people actually do to accomplish what they are doing, be it information seeking or information use.

In contrast to the fore-mentioned studies that have focused on actively information-seeking behavior where an information user interacts with formal information systems to find the needed information, and usually, for a structured task, there are also more recent studies that focus on how people seek information in a particular context (Information Seeking in Context) or for various purposes in their everyday life – **everyday life information seeking (ELIS)** (Savolainen, 1995).

In his influential 1995 paper, Savolainen proposed a framework for the study of ELIS in the “context of way of and mastery of life”. Here way of life is defined as the “order of things”, which manifests itself, for example, in the relationship between work and leisure time, models of consumption, and nature of hobbies. And mastery of life is “keeping things in order”. Savolainen (1995) sees everyday life information seeking as manifesting itself in the “monitoring of daily life world”. In the framework, four ideal types of mastery of life are hypothesized, namely optimistic-cognitive, pessimistic-cognitive, defensive-affective and pessimistic-affective. It is conceived that ELIS has two major dimensions: the seeking of orienting information, and the seeking of practical information.

Those forms of information behavior do not necessarily involve active or purposeful information seeking. They encompass a wide range of practices that can be active information seeking like most library and information science studies have focused on, or serendipitous as encountering some unexpected information, miscellaneous fact, or situation that may help in meeting some future need. Ecological theory of human information behavior by Williamson (1998) also emphasize that information is often incidentally acquired rather than purposefully sought (at least in the field of everyday life information). Recently there have been more studies that are concerned with people's everyday life information seeking. Agosto and Hughes-Hassell (2006) studied urban young adults' needs for everyday life information and proposed a theoretical and an empirical model.

Information Seeking in Context

“An ‘information science’ firmly founded upon an understanding of information users in the context of their work or social life is also likely to be of more use to the information practitioner, by pointing the way to practical innovations in information services, and to potentially beneficial associations with other communication or information-related subsystems.” (Wilson, 2006)

In another diagram, Wilson depicts the “universe of knowledge” (see figure 2.1.1.5) as the context of information seeking as an attempt to show some of the contexts within which information needs investigations are carried out. He believes that the slow progress towards some theoretical understanding of the concept of “information need” is due to the failure of identifying such context and the failure of doing “cumulative” research. As shown in the diagram, an information user has contact with “reference groups” around him in his life-world, which can be fellow professionals or the peer group within an organization, etc. The user can interact with information resources directly or through a mediator or technology. The paths marked with letters are intended to show some of the possible search paths or strategies. By categorizing an information user’s possible search paths or strategies, this diagram points out possible research avenues for investigating particular aspects of information-seeking behavior.

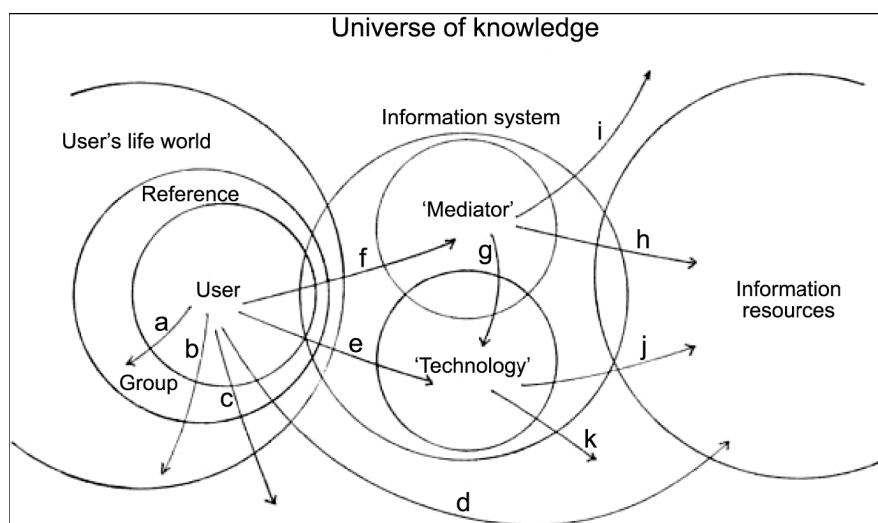


Figure 2.1.1.5: The context of information seeking

Of all the paths Wilson points out in this diagram for the context of information seeking, a few are of particular interest of this proposed study: the interaction between an individual (an information user) and people around (i.e. the reference group), the interaction between an individual and information resources, and the mediated interaction between an individual and information resources by mediator or technology. In the Virtual Math Teams community, small groups of students engage in math problem solving collaboratively. Members of a group need to share with others their ideas, present their arguments, provide explanations, ask questions, etc. The group is the direct resource for the participants and we expect to see that more information-seeking from the group

would naturally occur compared to an individual setting. The interactions of the “virtual teams” are entirely mediated by the online environment and the group interactions are preserved in the system for later access, which include the log of the conversation, the math objects and discussions participants developed on the shared whiteboard, and in some cases, their summarization of the work either in the chat room or in the VMT wiki dedicated for their sharing the work and knowledge building. All these along with other online resources constitute a corpus of information resources they could turn to. Participants can directly interact with the resource, for example, by recalling what they did in the last session (for groups who have worked in different sessions over time), or refer to the record of work by using features provided in the environment.

A review of select models on human information behavior suggests that many of them are built upon a cognitive premise and some are behavioral. They are valuable in the sense that they point out some important constructs and their relationships for studying or they provide findings of patterns of people’s information seeking within a particular setting. However, their focus on *individual* minds or *individual* behaviors limits their capacity of capturing the phenomenon of information practices of groups, especially in the setting of social computing. The observed changes in information behavior and information resources, particularly for youth in the digital age, have been brought to the attention of the research community by Dresang (1999). She developed the theory of *radical change*, which includes digital age principles – interactivity, connectivity, and access – to explain many aspects of information behavior and the design of information resources in the digital age. Connectivity refers to the sense of community or construction of social worlds that emerge from changing perspectives and expanded associations.

In traditional information seeking and use studies, information has been implicitly or explicitly cast as description of *reality*. In recent years we see emerging a number of approaches that attempt to bring a more structural, social analysis to information seeking and use, or a more phenomenological, lived experience view. Dervin’s **Sense-Making** methodology (Dervin, 1983) has been developed and established as a meta-theory or a conceptual tool in understanding the relationship of communication, information, and meaning. Associated with an emphasis in shift from a systems-centered to a user-centered perspective, Sense-Making theory considers that people are always facing “gaps” between their situation and their state of knowledge and they are constantly trying to make sense of the situations around them, which invokes “everyday” needs for information. The metaphors of situation, gaps, and uses are used to depict information seeking and use as a sense-making process. As Dervin puts it: “This brings us to a derivative axiom – the idea that it is a mandate of the human condition to bridge gaps.[...] it says we assume there is pervasive gappiness: in observing, in reality. Existing and being requires that humans move forth through time-space.” (Dervin, 2003) “Not only are we assuming pervasive gappiness in human observing that can in no way be resolved or bridged by external standard, we are also positing inherent gappiness in physical reality that can also in no way be absolutely and irrevocably bridge.” (ibid) The existence of gaps mandates people construct “bridges” in order to move along in the journey of making sense of the surrounding world.

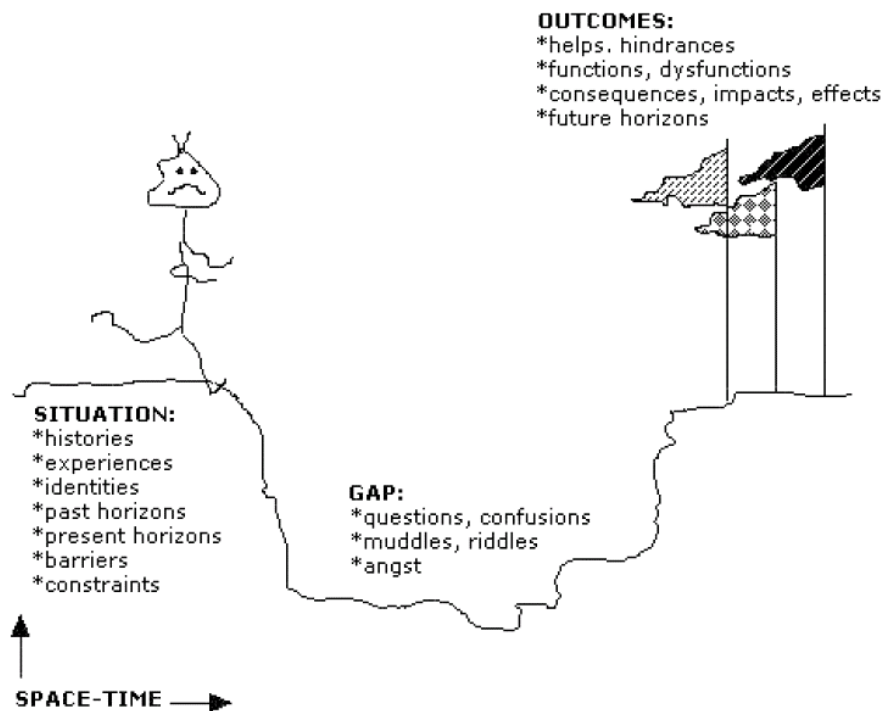


Figure 2.1.1.6: Facing a gappy situation. From “Sense-Making Methodology: Communicating Communicatively With Campaign Audiences” by B. Dervin & M. Frenette, 2003. In B. Dervin & L. Foreman-Wernet (Eds.), *Sense-Making Methodology Reader. Selected Writings of Brenda Dervin* (p. 238). Cresskill, NJ: Hampton Press.

We are positing a world that is itself discontinuous at least in part and an observer who is necessarily bound in time-space and who makes observations of reality from that time-space via a set of processes which are inherently gap-filled. All bridges made across these gaps are constructions. Information in this formulation becomes that which informs. That which informs is that which bridges gaps. That which bridges gaps is necessarily that behaving, that constructing, that sense-making that built the bridge. (Dervin, 2003, p300)

Sense-Making as a methodology rests on this core gap metaphor which posits humans facing stops (that moment where a gap is seen ahead) and constructing bridges in order to keep moving through time-space. Sense-Making as a methodology has been developed to address general issues in human communications but it has significant implications for the field of information science and has been developed a set of studies as its own right. The formulation provided by Sense-Making has several implications for information seeking and use. One is that instead of talking of *processing* information, Sense-Making views information as informing and informing as process. Another basic assumption implied by this formulation is that the observing cannot be meaningfully taken out of the time-space where the observing is being made. The stress on situated context suggests that information seeking and use (i.e., the seeking and use of sense) cannot be understood outside the situated context but that it is possible to draw on the gap metaphor to construct ways of studying these phenomena systematically across time and space in a way “pertinent to specific moments in time-space”. Sense-Making assumes that articulation of one’s *lived experience*, including its “struggles and resistances as well as alignments with given order”, is in itself a Sense-Making journey.

Most studies on information seeking and use focus on habitual patterns. Under such premise, the questions they ask are what kinds of people seek what information and they try to extract habit patterns that link people conceptualized as static entities to information which is also conceptualized in static boxes. The emphasis on habits in behavior assumes that a given person applies the same strategy in the same way looking for information across time and space. “Sometimes this extends to a focus on behavior strategies in particular kinds of situations with the situations defined externally in the categories of the dominant system. The question is whether the seeker seeks one way in one kind of context and another in another kind.” (Dervin, 1983). The history of all this work has typically shown low explanation and variance accounted for.

Most studies assume information as a given, as isomorphic description of a real world. Given this assumption, most studies also implicitly focus on information transmission as outcome as if the receipt of information was sufficient. In Dervin’s view, this privileges outcome over process.

In contrast, Sense-Making mandates attention to process, not eliminating attention to outcomes but setting outcomes into process. This interrupts the usual emphasis in information seeking and use studies on “the” outcomes as defined by the system and admits multiple outcomes, even contradictory ones. This mandate is best illustrated in the Sense-Making interview approaches where actors are routinely asked “how” things came to be (E.g. what led to this? How did it connect to your life? How did you get an answer?) as well as “how” they evaluated events (e.g., how did it help? How did it hinder?). (Dervin, 1999)

Dervin thus proposes seeing information as a verb instead of a noun:

“a focus on verbings offers a different entry for the search for systematic understandings of the human condition. Instead of focusing on elusive, ever-changing and constantly challenged nouns, Sense-Making mandates a focus on the hows of human individual and collective sense-making and sense-unmaking, on the varieties of internal and external cognizings, emotions, feelings, and communicatings that make, reinforce, challenge, resist, alter, and reinvent human worlds” (ibid, p. 731).

Conceiving information as a verb requires us look at the ways in which people “informationally” design and shape their worlds. This approach to information also *makes no distinction between knowledge and information* (Dervin, 1998). Dervin believes that knowledge versus information are system distinctions of no meaning to lived experience and movement through time-space. Thus, it is of secondary importance whether the input to sense-making is defined as information or knowledge. Information-knowledge is seen “as product of and fodder for sense-making and sense-unmaking” (Dervin, 1998).

Sense-Making methodology can serve as a particularly powerful conceptual tool to guide the study on the meaning making process in information use in that it suggests what questions to ask (i.e. “how” questions) therefore urges researchers to look into the processes and outcomes of information practices as lived experiences. It however does not provide details on how such studies should be designed, although some examples of studies under Sense-Making methodology offer methods that can be generally described as surveys or questionnaires. Those methods as research instruments are designed to

solicit participants' self-account of their experiences, which offers insights into what really happened but nevertheless not the same. This will be discussed in the methodology section of the dissertation. Our stance in treating the conception of "information" aligns with what Sense-Making methodology proposes in that we are not interested in seeing "information" as an object that could be transferred between a sender and a receiver but rather something which participants together construct meaning and make sense of and apply to their problem solving. Our study is grounded on the premises of Sense-Making and exemplified how information behavior can be studied and approached from an interactional perspective.

2.1.2. Collaborative information behavior

Collaboration has been a more and more common practice nowadays, either in the setting of work, learning, entertaining, or social networking. Collaborative practices have started to assume a more and more important position especially with the emergence of social computing applications. It would be surprising to find that information behavior has not been studied in collaborative settings. Collaboration started to catch the interest of information scientists in quite early years but the studies on examining collaborative information behavior only started quite recently. One well known example of early IS study on collaboration is Allen's (1977) description of the gatekeeper phenomenon, where a gatekeeper takes the responsibility of looking for information and forwarding to his/her colleagues in the team or organization. There have been studies on collaborative filtering (e.g. Maltz & Ehrlich, 1995) and collaborative browsing (Twidale, Nicholas, & Paice, 1997), most of which investigated information behavior in collaborative settings, even though the process itself is not assumed to be performed collectively.

Some recent studies have tried to look at the collaborative information seeking behavior of groups within working contexts or military contexts. Hertzum (2002) studied how a team of software engineers assessed and chose their information resources. Fidel et al (2004) reported the study on collaborative information seeking of two software design teams across organizations. Bruce et al (2002) analyzed two design teams at the beginning stage of a software engineering project and identified that collaboration of information seeking takes place when they are analyzing and defining their information problem and devising information seeking strategy. Sonnenwald and Pierce (2000) conducted a qualitative study that explores information behavior in a command and control military context whereas Prekop (2002) analyzed the information behavior of a military working group established to review command and control capability of the Australian Defense Force. A very recent work of Hyldegard (2006) reported a preliminary case study exploring Kuhlthau's Information Search Process (ISP) model in a group-based educational setting.

In summary, collaborative information behavior has been investigated in library context, academic and other professional settings, and in everyday life contexts as well. Together, these studies suggest information behavior in collaborative settings may be quite different from individual settings and more remains to be discovered. Most of the studies brought in similar research methods that have been traditionally applied in individual information behavior. Those methods mainly include questionnaires, interviews (face-to-face or over phone), diaries/journals, etc as means to solicit users' own accounts of their activities. Observation is also a commonly used method in studying

collaborative information behavior. Researchers usually tend to set up some variables that are meant to capture the phenomenon of interest and variables that characterize the setting and draw relation between them. Individuals are the unit of analysis in most of these studies, which means the collaborative setting is only considered as background of individual activities of some sort. Information behavior thus is considered as a collection of individuals or they study how individuals deal with information differently in a group setting. In this sense, studies on collaborative information behavior are not much different from other studies that take into account of the context of information behavior.

It has been argued that studies on information seeking in context have applied “objectified” approaches to context, that is, various environmental and social factors are seen to affect individuals’ and groups’ behavior, which remains the focus of research. It could be argued that when the object of research is defined as “patterns of behavior”, information needs, seeking and use are not studied as social and cultural phenomena, since social, cultural and historical factors are still treated as outside factors. Vakkari (1997, p. 462) concludes that although information needs and seeking are more and more studied as embedded in the phenomena they support or are part of, this embeddedness seldom includes other than individual level variables.

However, collaboration is not simply a collectivition of individual efforts. Theories and studies on collaboration have shown that being in a collaborative group, members produce what they cannot possibly have done individually (Bereiter, 2002; Stahl, 2006b). In order to understand how collaboration and learning take place, merely looking at individuals is not sufficient. We have to treat the group as a whole and look closely into the micro-level details of interactions. Under the setting of collaboration, information “behavior” is taking place within broader social practices, “the concrete and situated activities of interacting people, reproduced in routine social contexts across time and space” (Rosenbaum, 1993, p239). A focus on practices rather than on behavior shifts the analysis from cognitive to social and is consistent with the study of information seekers within their social context.

2.1.3. Theoretical perspectives of studies on information behavior

In his review paper on user studies and information needs and studies, Wilson (2006) points out the problem in the field lies with the troublesome concept of “information”, that is, a failure to use a definition appropriate to the level and purpose of the investigation. The information transfer model has been the most commonly used meta-theory in information science, especially in traditional studies on information behavior. In this model information is seen as an abstract entity that is possessed by the sender of the message. The sender is an expert who forms knowledge by observing the world. The model assumes that knowledge, constructed by observing a phenomenon, reflects it like a mirror. The task of the sender is to transport this mirror intact from his mind to the mind of the receiver. One needs a mechanism to carry the message. Thus, language functions in the model like a conduit in which the “information brick” can be put in order to be transported between the sender and the audience. Belkin (1978) notes that:

The most commonly proposed information concept for information science . . . is that of Shannon . . . This is hardly surprising, since Shannon’s information

concept is almost the only formalized, mathematical, and successfully implemented concept ever proposed for any purpose (p. 66).

More recently, it has been recognized that the communication model proposed by Shannon, with its elements: source, channel, message, coder, decoder, receiver and noise, was never intended as an information-science model nor as a behavioral science model. It consequently doesn't tell us about the information user and his needs. Wilson thus advocates that the concepts we need for explanation, or for development within our own emergent discipline need to be drawn from psychology, social psychology and sociology, as much as from communication theory.

The concept of information has always been one of the most discussed topics in the field of information science since it came into being and researchers have very different views on conceptualizing information due to their commitment to different theoretical premises. For example, the points of view of *Information-as-process*, *Information-as-knowledge*, *Information-as-thing* have been discussed in Buckland's (1991) seminal work. Saracevic (1999) analyzes the three senses of "information" in information science. The narrow sense of information considers it as signals or messages for decisions involving little or no cognitive processing, or such processing that can be expressed in algorithms and probabilities. Information is treated as the property of a message, which can be estimated by some probability. Examples include information in terms of uncertainty in information theory and "perfect information" in game theory. In the broader sense, information is treated as directly involving cognitive processing and understanding. It results from interaction of two cognitive structures – a "mind" and a "text". Information is that which affects or changes the state of a mind. In the broadest sense, information is treated in a context. That is, information involves not only messages that are cognitively processed, but also a context, which can be a situation, task, or problem-at-hand. According to Floridi (2002b), the human mind "needs to make sense of its environment by continuously investing data (affordances) with meaning" (p 129). Information is defined as "meaningful data". Dervin makes no distinction between knowledge and information because she sees they are system distinctions (see earlier discussion).

The underlying theoretical premise of studies of Taylor and Belkin is cognitive viewpoint, which has been the prevailing approach in information retrieval research by the time. As De Mey (1977) states: "The central point of the cognitive view is that any processing of information, whether perceptual or symbolic, is mediated by a system of categories or concepts which, for the information-processing device, are a model of his world." Some later behavioral studies take a different theoretical premise than cognitive viewpoint in the belief that behavior offered a more tractable focus of study than cognition and that a behavioral approach to user modeling would be more feasible than cognitive approach. This approach to modeling information-seeking behavior originated from a perceived absence of empirically based models of such 'behavior' in information retrieval research. These models focus on describing general information seeking or information behavior in a larger scope other than only focus on the information needs part. They sought to identify patterns in information behavior that can be applied to the development of information retrieval systems.

At the heart of each conceptualization of information lies the theoretical premise. For example, the once dominating cognitive approach rests on constructivism as the metatheory. In contrast to information transfer model which see information as an

“object”, constructivism conceives of information as a *subjective matter*. The cognitive viewpoint is defined as an approach and a set of constructs for understanding information behavior, which focuses fundamentally upon *attributes of the individual*. Many studies with this cognitive orientation try to find out patterns of information behavior under a particular *context* and try to attribute the patterns to certain characteristics of the users, the context, etc. They tend to examine the cognitive and emotional *motivations* for information behavior that carry across contexts or are independent of context. The social cognitive distinguishes from this by treating context (particularly attributes of the social and organizational context) as the focus for understanding information behavior.

More recent years have seen the emergence of social constructionism in information and user studies. The main advocates of this distinct theoretical orientation are Talja, Tuominen, and Savolainen. Instead of viewing information as an entity with fixed boundaries or as a commodity that is transferred through communication, social constructionists define information as “a communicative construct which is produced in a social context”. As they further explain: “the contextual nature of information means that the way in which a version of information is constructed always depends on the interactive nature or argumentative context of talk, as well as on the pragmatic social purposes this version is designed to accomplish”. Social constructionism (sometimes also called constructionism) in the widest sense is a synonym for “the linguistic turn” in human and social sciences. The primary emphasis is not on mental, but *linguistic processes*. Seeing language as constitutive for the construction of selves and the formation of meanings, it emphasizes discourses, articulations and vocabularies, and replaces the concept of cognition with conversations. In contrast to this, we take an interactional approach, treating information as interactionally achieved in and through the interactions among actors.

Constructivist approaches are more commonly applied in empirical information seeking studies than constructionist approaches. Most traditional studies tend to focus on channels or resources of information based on some certain kind of personal account or personal disclosure such as using survey or interview to elicit answers to pre-structured questions. Few focuses on the process itself like formulation of information needs and inquiries or the dynamic process of information seeking and use, which seems to be what virtual teams at VMT always engage in. We also noticed that at VMT, students often have difficulty applying a math concept to their problem at hand. This is not surprising since being able to use math knowledge to solve different problems is one of the most important and also challenging skills in learning mathematics. We believe that understanding of information practices in VMT environment has to be put within broader social practices, which invites a constructionist analytical approach. For example, the virtual teams together build on each other’s ideas and construct knowledge during the process of collaborative problem solving. Such locally produced information, or knowledge, may become meaningless if taken out of context, which subsequently requires certain interactional work from participants in order to for them to share with other groups or make use of. This echoes to the point of constructionist that information or knowledge formation is contextual and dialogical, and knowledge is a negotiated discursive construct that is created between people (Tuominen & Savolainen, 1997).

Constructionist studies in information science have mainly remained on a metatheoretical and philosophical level and have not generated sustained empirical

research programmes and methodologies (Ingwersen, 1999, p.33). More recent years have seen more applications of constructionist ideas in information science. For example, using a social constructionist approach, Tuominen & Savolainen developed a framework for studying the concept of “information use” as a form of discursive action. Focusing on everyday settings, they followed Harre’s social constructionist tenet that “the primary human reality is persons in conversation”. In the field of everyday-life information seeking, Given (2002), McKenzie (2003, 2004), and Tuominen (2001) are constructionist empirical studies that focus on participants’ *discursive accounts* of their information needs and seeking. They show how information practices – often analyzed from a behavioral perspective – look different and reveal new sides when looked at as part of the social negotiation of meanings. The implications of constructionism for the development of digital libraries are also being discussed. Pettigrew’s (1999) empirical study showed how sensitive issues like information sharing in clinical services can be analyzed by utilizing a constructionist understanding of information as an interactional accomplishment.

2.2. Review of relevant research in Learning Sciences and CSCL

2.2.1. Evolution of research methods for studying collaborative learning

The transformation of theoretical perspectives in information science research coincides with what has taken place in the field of learning sciences with respect to the conception of what constitutes learning. Three metaphors of learning have been developed. The acquisition metaphor (Sfard, 1998) sees learning as individuals acquiring knowledge that is stored in the minds. This is corresponding to the information transfer model, where users are seen as receivers of objective information that is transferred from the sender. The participation metaphor sees learning as consisting of increasing participation in communities of practice, which reflects a social perspective (Brown, Collins & Duguid, 1989; Lave & Wenger, 1991; Hanks, 1991; Wenger, 1999). The third metaphor was developed by researchers including Lipponen, Hakkarainen and Paavola, (2004), Bereiter (2002) and Engeström (1987) in which learning is viewed as knowledge creation: knowledge or social practices are created in the social world through collaboration.

This shift in focus also aligns with two main different methodological traditions in Computer-Supported Collaborative Learning (CSCL) research, namely experimental and descriptive (Stahl et al, 2006). Three stages in the field’s history of methodological development can be identified from recent reviews of collaborative learning research, namely (a) the effects paradigm (b) the conditions paradigm, and (c) the interactions paradigm (Dillenbourg et al., 1995; Webb & Palincsar, 1996; Cohen. 1994; Baker, 2002). Initial efforts in collaborative learning research treat collaboration as a black box, and attempt to measure its *effects* on learning via controlled experiments. The first two paradigms are loosely corresponding to the experimental methodological tradition while the third – the interactions paradigm – usually falls into descriptive tradition. Many empirical studies in CSCL have followed the experimental tradition, using categorized independent variables (factors) to account for the phenomenon at investigation, usually reduced to a set of dependent variables also by applying predefined codes. These studies

brought conflicting results, most of which favored collaborative learning over individual learning, but revealed little insight about its nature. Later on, the focus of the field shifted from measuring the effects of collaboration to identifying the main *conditions* under which effective collaboration can be observed. For that purpose several variables that were hypothesized to predict effective collaboration such as group size, task types (e.g., jigsaw designs), group composition (e.g., pairs at same/different developmental levels), and gender were studied. However, these variables turned out to be interacting with each other in complex ways, which made it difficult to design experimental studies that can single out the effects of a given variable and hence aid the interpretation of statistical outcomes.

Recently, alternative methods focusing on the micro-level, moment-to-moment details of *interactions* have been proposed as an alternative to the experimental methods which are rooted in psychological tradition (Barron, 2000; Sawyer, 2006; Stahl, Koschmann & Suthers, 2006). These studies draw upon discourse analytic and conversation analytic traditions in social sciences, use actual recordings of interactions (e.g. video recordings, computer logs) as data instead of solely focusing on exam scores, and attempt to characterize important patterns in student-student and teacher-classroom interactions. Such descriptive tradition is aligned with ethnomethodological method (exemplified by Stahl, 2006; Koschmann et al., 2003; Koschmann et al., 2005; Roschelle, 1996) to conduct analysis on a micro level, often examining brief episodes in great detail. Even though CSCL research has been pursuing understanding collaboration and learning, most conventional studies take individuals as the unit of analysis, investigating how individuals behave in a group setting whereas group is only taken into account as the context or environment for individual's behavior. Instead of starting with a preconceived notion of what effective collaboration is and focusing on external measures indicative of it, the new methodological approaches focus on understanding how collaborative learning is done as an interactional achievement of collectivities such as small groups or classrooms through case studies of moment-by-moment interactions (e.g., Roschelle, 1996; Roschelle & Teasley, 1995; Stahl, 2006; Koschmann, Stahl & Zemel, 2007; Koschmann & Zemel, 2006).

The complicated nature of social interactions both at the small group level and at the classroom level motivated not only the use of naturalistic inquiry (Lincoln & Guba, 1985) methods for analytic purposes, but also the development of iterative approaches to instructional design as part of longitudinal efforts for incorporating pedagogies based on collaborative team work in classroom settings (Cobb et al., 2003). Such iterative approaches in educational research are referred to as Design-Based Research (DBR), where researchers continuously modify their tasks and interventions to facilitate and sustain collaborative knowledge building in the classroom and/or online. Due to this approach's success in investigating learning both at individual and small group levels, DBR has become a prominent methodology for educational research and instructional software development (Barab, 2006).

2.2.2. Studying “troubles of understanding” in learning situation

Recent discussions around what the central phenomenon of the interest of the research community of CSCL should be have reached some agreement that it is about “meaning making”. “*Intersubjective meaning making*” was proposed as a research agenda for the

field (Suthers, 2006). In his keynote talk at CSCL 2002, Koschmann (2002) defined the central concern of the CSCL field as “meaning and practices of meaning making in the context of joint activity and the ways in which these practices are mediated through designed artifacts”. Suthers has elaborated on this definition and proposed as follows: “The technology side of the CSCL agenda should focus on the design and study of *fundamentally social technologies* that are *informed by the affordances and limitations of those technologies for mediating intersubjective meaning making.*” (Suthers, 2006) (emphasis in original). Similarly, Stahl et al. (2006) argues that “the goal for design in CSCL is to create artifacts, activities and environments that enhance the practices of group meaning making” (Stahl et al, 2006).

Troubles of understanding are inseparable to meaning and meaning-making, if we consider meaning-making as process participants engage in resolving troubles of understanding in order to construct shared understanding or meaning. Current research literature in Computer-Supported Collaborative Learning (CSCL) and Computer-Supported Collaborative Work (CSCW) suggests that there are three main “barriers” related to meaning and meaning-making that groups have to overcome in order to have successful collaboration. These include: a) common ground barrier, which refers to differences of how each participant understands an idea or an action; b) epistemic barrier, which refers to the differences between each participant’s knowledge and competencies; and c) unshared knowledge barrier, meaning the gaps caused by shared and unshared knowledge (Bromme, Hesse, & Spada, 2005). In fact, the locating of sources for understanding troubles can be traced back to Vygotsky’s social constructivist view of learning, one of the social learning theories that CSCL is oriented to. According the theory, learners play an active role in constructing their knowledge and understanding in a social context. One of the central concepts that Vygotsky’s theory is built upon is the Zone of Proximal Development (ZPD), which measures the difference between what an individual learner could achieve with scaffolding (Wood, Bruner, & Ross, 1976), such as the help of a more competent, knowledgeable learner or tutor, and what he could achieve alone. This concept depicts epistemic differences between learners in a group and at the same time suggests one mechanism that “learning” could be achieved is through the two learners with different competencies working together and construct meaning with the help of the more competent one.

One of the mechanisms for peer group learning related to the concept of ZPD is *peer explaining* (Chi, 2000; Webb, 1991, 1992, 1989, 2003) and *questioning*. *Asking questions* has been considered by many researchers to be central to theories of learning, cognition, and education (e.g. Scardamalia & Bereiter, 1991; Graesser, 1994; Ram, 1991). Some believe that the ability to ask questions is pivotal in processes of reasoning, understanding and learning. Questions are, for instance, a powerful and ubiquitous tool used in instructional interactions. An *IRE* (Initiation-Response-Evaluation) model (Mehan, 1979) has been commonly used in classroom settings, the sequence of which is 1) an instructor asks a question for which he or she already knows the answer, 2) students respond to the question, and 3) the instructor evaluates their response (Fox, 1993; Wells, 1999). Studies of the role of teachers’ question asking in classroom settings have considered it a means by which teachers retain control within their students’ zones of proximal development (Scardamalia & Bereiter, 1991). Studies of questions in classrooms and one-to-one tutoring settings have suggested certain questions for teachers to ask to guide student

thinking and to shift students toward more reflective discourse (e.g. Van Zee & Minstrell, 1997; Graesser, 1994). Previous studies have confirmed the importance of elaborated explanations and shown that constructively applying the help received is beneficial for learners (e.g., Webb et al., 2006). In mathematics education, in particular, reform efforts have called for student-centered communication. The National Council of Teachers of Mathematics (NCTM, 1991, p. 35) lists a number of desired teacher behaviors such as “posing questions and tasks that elicit, engage, and challenge each student’s thinking; listening carefully to students’ ideas; asking students to clarify and justify their ideas orally and in writing; and monitoring students’ participation in discussions and deciding when and how to encourage each student to participate.”

Although question asking is believed to lie at the heart of learning, it is well documented that students very infrequently ask questions in the classroom, and that their questions tend to be “lower-level” questions (Webb, Nemer, & Ing, 2006). Educational researchers have frequently advocated educational settings that engage students in active learning and problem solving, which often involves students in formulating their own inquiries and asking effective questions. CSILE (Computer-Supported Intentional Learning Environments) is a prominent example of a learning environment designed to support students’ intentional learning by encouraging students to ask questions and then using these questions to guide their knowledge building (Scardamalia and Bereiter, 1994).

The power of peer explaining, including giving and receiving explanations, in small peer groups has been explored by many researchers. Empirical studies have shown that giving explanations relates positively to achievement of the one who gives an explanation although the relationship between receiving explanations and learning outcomes proves to be inconsistent and weak. It also has been consistently shown that receiving no responses to questions negatively relates to achievement or learning outcomes. Studies have also been carried out to find out what conditions effective explanations require, among which one is that students apply the received explanations to problem at hand (Vedder, 1985). It has also been brought up to attention that in group work, students may be reluctant to ask questions in order to avoid looking incompetent (Mastergeorge et al., 2000). Explanations are more likely elicited when a more “specific” question is asked and the help seeker is persistent in asking for help. Existing studies have suggested that questioning and explaining are important interactional mechanisms through which small groups construct shared meaning and “learn” together. Pre and post tests are often used in those studies to measure students’ understanding in order to measure “learning outcomes” or achievement. Questions are also treated as individual objects independent to the interaction where questions happen or in other words, researchers assign meanings to those questions based on their subjective understanding of what is going on. Such methods are concerned about pre-assigned variables and the correlations among them as ways to represent and interpret the phenomenon of interest. Studies using such methods therefore do not look into the processes and practices of how learners themselves are oriented to attending to their troubles, which are precisely what we need to understand.

Another mechanism of attending troubles of understanding called “grounding” (Clark & Brennan, 1991; Clark & Schaefer, 1989) is based on a communication theory of “common ground” that is commonly used and referred to in CSCL studies to describe the processes of co-constructing shared understanding between two interactants. The “common ground” model describes the ways dyads in conversation coordinate their

mutual knowledge, mutual beliefs and mutual assumptions in order to reach aligned mental contents (common ground) for their interaction to proceed. Although originated from the interest to understand the interactional process of “grounding”, the concept of “common ground” however has often been used more as an object of individual mental representation. Koschmann and LeBarron (2003) has criticized the model by arguing that the notion of common ground is rather “a place where things can be stored and recorded, but this is a profoundly misleading connotation...common ground is, after all, a place with no place. It is a cooperatively constructed mental abstraction, available to no one” (Koschmann et al., 2001).

Other mechanisms related to attending to the troubles of understanding with focus on interactions include argumentation built upon and derived from cognitive conflict (Andriessen, Baker, & Suthers, 2003; Weinberger & Fischer, 2005) and intersubjective negotiation or negotiation of perspectives (Stahl, 2003, 2006b; Stahl & Herrmann, 1999; Nathan, Eilam, & Kim, 2007). Roschelle (1992) has argued that it is through achieving convergence of conceptual change that multiple participants in a group construct shared meanings and that the crux of learning by collaboration is convergence. He analyzed from the point of view of conversational interaction how dyads negotiated their conceptualization of velocity and acceleration and arrived at a shared new conceptualization that is more compatible with the scientific interpretation. Barron (2003) reported a study with 6th-grade triads to investigate how collaboration interactions influence problem-solving outcomes, suggesting the quality of interaction has implications for learning. It was found that both characteristics of proposals and partner responsiveness were important correlates of the uptake and documentation of correct ideas by the group. Neither prior achievement of group members nor the generation of correct ideas for solution could account for the differences in problem-solving outcomes between triads. Those researches point to and highlight the need for studying the interactional mechanisms through which collaboration and learning are achieved, or in other words, shared meanings are constructed collaboratively in small groups. And such studies require an orientation to the processes.

2.3. More reviews on questioning and troubles of understanding

Our observations of VMT sessions and preliminary analysis of some episodes of interactions have shown that questioning (and explaining that follows in response to questioning) is a common way that participants use to initiate their troubles of understanding. In this section, we review some studies and approaches to the phenomenon of “questioning” that we consider as particularly relevant to our proposed work.

2.3.1. Questioning in studying librarian services

Questioning has long been associated with “information needs” of users of information systems ever since the conception of the field of information science (Taylor, 1962; Horne, 1983). Librarians have been concerned with the process of asking questions that patrons may go through in order to better bring the generator and the users of information together. Taylor (1962) has discussed question’s generation, its relation to the retrieval system, and its effect on the inquirer. Four levels of question formation have

been outlined in the form of “information needs” that are associated with the inquirer’s “state of readiness”, namely, the actual, but unexpressed, need for information; the conscious within-brain description of the need; the formal statement of the question; and the question as presented to the information system. The later ASK model of anonymous state of knowledge (Belkin,) on interaction between information user and information retrieval system draws heavily on those levels of needs. Taylor later reported a study of the process of question negotiation between patron and librarian using taped interviews with special librarians and information specialists (see Taylor, 1967). The study identified five levels of information which are consciously sought and received by the librarian which include subject definition, objective and motivation, personal characteristics of the inquirer, relationship of inquiry description to file organization, and anticipated or acceptable answers. Wu (1993) proposes a conceptual framework called micro-level information seeking (MLIS) for the elicitation process to describe “questioning” in the areas of library reference services and information retrieval interaction. It applies Dillon’s elicitation elements (assumption, question, and answer) and emphasizes the internally and externally “driven forces” that create the need for elicitation.

The more recent years have seen the emergence of virtual reference services offered by libraries coping with the fast developing of virtual world. Studying interactions between librarian and patron in such virtual environments has attracted increasing research interest for understanding user behavior or for evaluation purposes. Among many of the studies, questioning and answering have attracted heavy attentions (Carter & Janes, 2002; Foley, 2002; Kaske & Arnold, 2002; White, Abels, & Kaske, 2003). Various approaches have been applied including both quantitative and qualitative methods. For example, the relational (socioemotional) aspects of virtual reference service have been explored applying communication theory to analyze transcripts of chats using content analysis (Radford, 2006). Lately, ethnomethodology (EM) and conversation analysis (CA) have been brought up to attention to researchers as a more nuanced approach to analyzing patron-librarian interaction in virtual reference (Epperson & Zemel, 2008; Koshik, 2009).

2.3.2. Conversation Analysis on troubles of understanding

The centrality of language use in the production and maintenance of social life has been acknowledged by sociologists. Language has been viewed as a means of symbolization (Mead, 1934), a primary component of the cultural system (Parsons, 1937), a primary example of a social fact (Durkheim, 1950), or a system of classification (Durkheim & Mauss, 1963). However, the use of language and its organization feature have been less pursued by sociologists until recently. The “objectivism” and “structuralism” such as Speech Act Theory (Austin, 1962; Searle, 1969) and the theory of communicative action (Habermas, 1987) is oriented to in approaching language have been critiqued in contemporary social theory. For example, Bourdieu attempts to remind analysts that language is *to be used* and that use is *situated* and urges the recognition of the fallacy underlying most versions of structuralism:

The illusion of the autonomy of the purely linguistic order that is asserted in the privilege accorded to the internal logic of language at the expense of the social conditions of its opportune use, opened the way to all the subsequent research that

proceeds as if mastery of the code were sufficient to confer mastery of appropriate usages, or as if one could infer the usage and meaning of linguistic expressions from analysis of their formal structure, as if grammaticality were the necessary and sufficient condition of the production of meaning, in short, as if it had been forgotten that language is made to be spoken and spoken pertinently.

(Bourdieu, 1990:32)

By merging Goffman's (see Goffman 1964, 1972, 1983) focus on the normative organization of interaction with Garfinkel's (1967) interest in the intelligibility of social action, Sacks and Schegloff, and later Jefferson, have developed a powerful method called Conversation Analysis (CA) for analyzing conduct and provided the groundwork for an entire discipline that explores interaction as a fundamental form of social organization. Conversation analysis provided the basis for a growing body of research that has revolutionized our understanding on how language is used, or in other words, talk-in-interaction is organized, in the production and maintenance of social life (Drew and Heritage, 1992; Goodwin, 1981; Heritage, 1984b; Jefferson, 1980; Sacks et al., 1974, Schegloff et al., 1977; Schegloff, 1968, 1992, 1995). Ethnomethodologists and conversation analysts seek to discover the interpretive practices through which interactants produce, recognize, and interpret their own and others' actions. This objective is one of describing the procedures by which conversationalists produce their own behavior and understand and deal with the behavior of others. A basic assumption throughout is Garfinkel's (1967) proposal that these activities – producing conduct and understanding and dealing with it – are accomplished as the accountable products of common sets of procedures. According to Garfinkel (1984a, p1), “the activities whereby members produce and manage settings of organized everyday affairs are identical with member's procedures for making those settings ‘accountable’”. Thus the ethnomethodology's (EM) approach to the analysis of action and its rationales is premised on the public accountability of action. EM/CA approach in understanding human actions (often with talk-in-interaction at the center) is premised upon that human actions are meaningful and involve meaning-making; actions achieve meaning through a combination of their content and context; and, to be socially meaningful, the meaning of actions must be shared.

One primary focus of CA is on the sequential organization of interaction, regarding the organization of action through sequences of turns at talk. Such observation embodies a claim that each utterance in conversation poses a here-and-now definition of the situation and the subsequent contributions are oriented to such situation (Heritage, 1984b; Jefferson, 1978a; Sacks, 1987; Schegloff, 1968, 1990b). By producing the next actions, interactants show an understanding of a prior action. For example, by providing an answer, an actor can show an understanding that the prior turn was possibly complete, that the question was addressed to them, and it was recognized as a question and so on. The understandings are confirmed (by the following actions) or can become the object of repair at a next turn (Schegloff, 1992b). Every utterance constrains the subsequent talk to different extent. While some only weakly constrains the next relevant actions, some actions can impose quite strong constraints on the next turn that only a narrow range of responses should follow. Some paired actions which are the most strongly organized sequences in interaction are observed which are termed “adjacency pairs” by Schegloff

and Sacks (1973). For example, if one greets, the greeting should be returned; if a question is asked, it demands an answer. This concept suggests a primary mechanism through which intersubjective understanding is achieved and maintained in interaction. A related concept introduced is “conditional relevance” Schegloff (1968):

By the conditional relevance of one item on another we mean: given the first, the second is expectable: upon its occurrence it can be seen to be a second item to the first; upon its absence it can be seen to be officially absent – all this provided by the occurrence of the first item.

The sequential organization of interaction provides interactants vital resources not only for building a routine grounding for intersubjectivity but also for recognizing breakdowns of intersubjectivity and repairing them (Schegloff, Jefferson, & Sacks, 1977; Schegloff, 1992). How recurrent problems in speaking, hearing, and understanding are addressed by “repairs” has been examined in CA. Several aspects of an “organization of repair” that operates in conversation have been reported including the distinction between self- and other-initiated repairs, the positions where the repair turn takes place in the sequence, and the different techniques used to design the initiation of repair (Schegloff, Jefferson, & Sacks, 1977). A mechanism that produces a strong empirical skewing in which self-repair predominates over other-repair is discovered – the preference for self-repair in the organization of repair. Later study extends understanding of the organization of repair to how repair is done in a third turn or next after the trouble-source turn (Schegloff, 1992).

Efforts to understand “misunderstanding” and repairs in talk-in-interaction have also led to the discovery of a number of systematic sources of misunderstanding (Schegloff, 1987). Such sources include seriousness vs. nonseriousness of the talk, a turn produced to do one action is taken by its recipient to be doing a different action, a limited class of utterances interpretable in either a “constructive” or a “composite” manner (for example, “what are you going to do” when understood “constructively”, a request for information and when “compositely”, it is a form of assessment or a form of stance taking), and “joke first”, which are regularly produced as intentional misunderstandings of the prior talk which has set the terms for the joking speaker’s talk.

2.3.3. Conversation Analysis on questioning

Questioning as activity has been studied by social scientists whose primary interest is the “interaction order” (Goffman, 1983) as a form of social organization. Question-answer has been recognized as one of the main types of adjacency pair sequence (Schegloff, 1968, 1984, 1995; Schegloff & Sacks, 1973). In an effort to show the gap between language and social behavior, Schegloff describes the complex relationship between the notion of “question” as a grammatical form and the action realized by it in an interaction (Schegloff, 1984). He demonstrates that on some occasions questioning is used by speakers to do other actions than the common notion of “questioning” such as a question seeking information. For example, by saying “why don’t you come and see me some times”, the speaker is not asking a question that the hearer answers but an “invitation” (in question form) that she “accepts”.

Questioning has been examined by social scientists in some institutional settings. For example, Heritage (2002a) looks at the situation where community nurses visit newly

delivered mothers within a few days of their return from hospital, collect standardized information about the family and its circumstances, which they record on the spot and study how the health visitors design their *routine* questions in search of standardized information. The reported central observation is that regardless of the specific aims of questioning, the ways in which questions are designed unavoidably serve to index particular relationships between questioner and respondent. Questioning has been studied in the settings of patients' visit to physicians, such as how the opening of question from physician is designed and how patients present their concerns (Heritage & Robinson, 2006) and the role of questioning in the management of the social relationship between doctor and patient (Heritage, 2010). Researches have also looked at questioning in the context of news interviews (Heritage, 2002b; Koshik, 2005). For example, negative interrogatives are found to be recurrently produced as, and treated as, a vehicle for assertions (Heritage, 2002b). Koshik (2002, 2005) also studied yes/no questions that convey reversed polarity assertions in daily conversations as well as in pedagogically specific practices. She also studied the occasions that wh- reversed polarity questions are used to challenge others or as complaints (Koshik, 2003, 2005). A question when designed as an alternative question can also be used to initiate repair (Koshik, 2005). Pomerantz (1988) has looked at offering a candidate answer as an information seeking strategy in mundane daily conversations.

Researches have also look at responses to questions. Starting from Sacks' (1987) paper on the preference for agreement and contiguity in conversation, ongoing researches have continued to build a developing body of knowledge about the design of questions and their uses. For example, studies have examined yes/no or polar questions such as the structure of responding by looking at type-conforming and nonconforming responses (Raymond, 2000, 2003, 2004; Heritage, 2010) and found out type-conforming responses tend to maximize the progressivity of the question-answer sequence towards sequence closure (Raymond, 2003).

The current conversation analytical studies around the topic of "questioning" are mainly focused on the interactions of dyads in face-to-face situation. Multiple participants in a small group interacting through online environments that consist of chat, a shared whiteboard, and other resources present us a unique setting for studying the design of questions and responses. In addition, participants are engaged in math reasoning and problem solving. The questioning organized around "troubles of understanding" under the circumstance involves interactional methods and procedures, some of which may be common in other settings such as mundane conversations but some may be fairly unique. The analysis we conduct to answer our research questions can contribute to this line of research on understanding questioning as a particular social action in the organization of interactions.

CHAPTER 3. RESEARCH DESIGN

3.1. The VMT Project and data collection

This proposed study is situated in a larger research agenda of the Virtual Math Teams (VMT) project, which has been an ongoing research project starting at year 2004. Researchers from various disciplines including information science, math education, anthropology, communications, and software development have been collaborating at VMT, working together towards building an online community of math discourse and an environment to support collaborative math learning. The VMT project has been a platform for designing Math Forum services and learning environments as well as an array of research work that are oriented around the practical issues, stressing on understanding of how students use the service and the environment, how they collaboratively work on math problems together and produce effective knowledge-building math discourse. The project has generated a very rich set of data that could be analyzed in accord to various specific research interests, for example, to understand Group Cognition, to investigate how virtual teams bridge their activities over time and across groups, to understand the meaning making process and the production of math objects, or to look into how a group resolves the differences among participants in order to collaborate, etc. The inquiry on troubles of understanding of the virtual teams looks closely into the group's meaning making process and understanding work. The research questions are investigated using the data from VMT.

VMT has a mix of goals, some are design oriented, e.g. designing and deploying a service as extension to the current Problem of the Week service at the Math Forum, and some are research oriented, e.g. studying such a new online service including the social interactions among the participants, the use of the service, etc. Because of the mix goals and the complexity involved in designing educational services, VMT has adopted a Design-Based Research approach in investigating the rich set of issues that are of concern of the project. Design-Based Research (Brown, 1992; Collins, 1992) is an emerging paradigm for studying learning in the context through the systematic design and study of instructional tools. It blends empirical educational research with the theory-driven design of learning environments thus is a proper methodology for studying issues that VMT aims to address, e.g. understand the use of chat environment for collaborative math problem solving and how an environment is used by students in practice etc. Under such methodology, development and research at VMT take place through iterative cycles of design, enactment, analysis, and redesign. In each cycle, instructional and technological interventions are introduced in naturalistic contexts, which are designed or changed based on close analysis of users' practices and experiences in the previous cycle.

The design of the VMT environment and services has gone through several iterative phases. In each phase, we set up a certain environment (all of them are synchronous chat based) and invited students to come to the sessions where a group of 2-5 work together collaboratively on a math problem. Students are recruited by their teachers from schools that the Math Forum has connection with, ranging from middle school to high school. The math problems given to the groups are designed by VMT researchers in the belief that they are interesting for students to work on and that they also provoke mathematical thinking. One facilitator from the VMT team will be present at each session to help

students get started such as orienting them to the environment and their task for the session. Facilitator also helps with technical problems when they arise. But the coordination of their task and the math discussion are totally left to the participants. Facilitation is never meant to be mentoring service for math in the VMT sessions. Each session is set to be about one hour long, considering the length of time that may be required to allow a relatively deep discussion on math and the limit of time participants are available. Sometimes the session can run a little longer. In some cases, students continued the discussion longer after the facilitator called it over and left.

We started with AOL Instant Messenger (AIM) chat tool in 2004 to experiment the idea of collaborative math problem solving in chat environment and wanted to see how it will be like. AIM was chosen because of its popularity in the age group of students (from middle school to high school) in the US. Most students have already been using it thus are familiar with it. It will be relatively easy to get participants started without acquiring and learning a new tool. The math problems participants worked on are the Problem of the Week at the time (at the Math Forum). AIM does not provide a shared space for drawings. So in the AIM sessions, facilitator also is in charge of helping participants post their drawings for the problem solving to a designated web site for them to be publicly visible to all the group members. From the experiences with the AIM sessions, the need for a shared whiteboard where participants could share their drawings of the problem emerges as somewhat pressing for such collaborative problem solving work in virtual environment. The VMT then tried out a product called Babylon that supports synchronous interaction along with a shared whiteboard. Experiences and analysis of the sessions tell us that more features are needed in order to facilitate such collaboration, learning, and doing math. We started to try ConcertChat, developed at Fraunhofer IPSI in Germany at the time, which initiated our collaboration with the researchers there to develop our own environment specifically calibrated to accommodate the needs for the virtual math teams. The stages of design and enactment can be briefly summarized in the following table:

Software Platform	Math Problem	Number of Sessions / Participants	Key Software Features
AOL IM Chat (2004)	Problem of the Week (PoW)	19 sessions with 19 different teams Group size: 2-5	Text based chat
Babylon (2004)	Ask Dr Math SAT Math questions	9 sessions with 9 different teams Group size: 2-4	Text based chat + Shared Whiteboard
ConcertChat (VMT Chat v1) (Spring Fest 05)	Taxicab Geometry (Grid World)	18 sessions with 5 teams Group size: 2-5 Each team participated in 4 sessions over two weeks	<ul style="list-style-type: none"> • Text based chat • Shared Whiteboard • Explicit Referencing Support • Other features: drawing tools, awareness messages, etc

VMT Chat v2 (Spring Fest 06)	Pattern Problems (including creating their own problems)	19 sessions with 5 teams Group size: 2-4 Each team participated in 4 sessions over two weeks	VMT Chat v1 features + <ul style="list-style-type: none"> • Lobby (as a chat room) • Basic Wiki Support • Math markup support
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VMT Chat v3 (Spring Fest 07 at Brazil, Singapore, Rutgers and used onwards)	Probability Problems	Sessions are ongoing ⁴	VMT Chat v2 features + <ul style="list-style-type: none"> • Integrated Tabs on whiteboard: summary, shared browser, collection of information resources) • Lobby as a web portal with social networking support • Advanced wiki support
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Table 3.1.1: Design Phases of the *VMT Chat* service

The current VMT Chat environment consists of a web portal (which we call the Lobby), VMT Chat rooms, and VMT wiki. The Lobby is a central place for users to do all kinds of activities, such as browse the math problems created, connect with other users, get help with setting up the environment and using the chat rooms, find chat rooms created for specific problems, or glimpse activities taking place at rooms, and so on. From the Lobby one can choose to enter a chat room or go to the VMT wiki page dedicated for a particular problem or room. (See Figure 3.1.1)

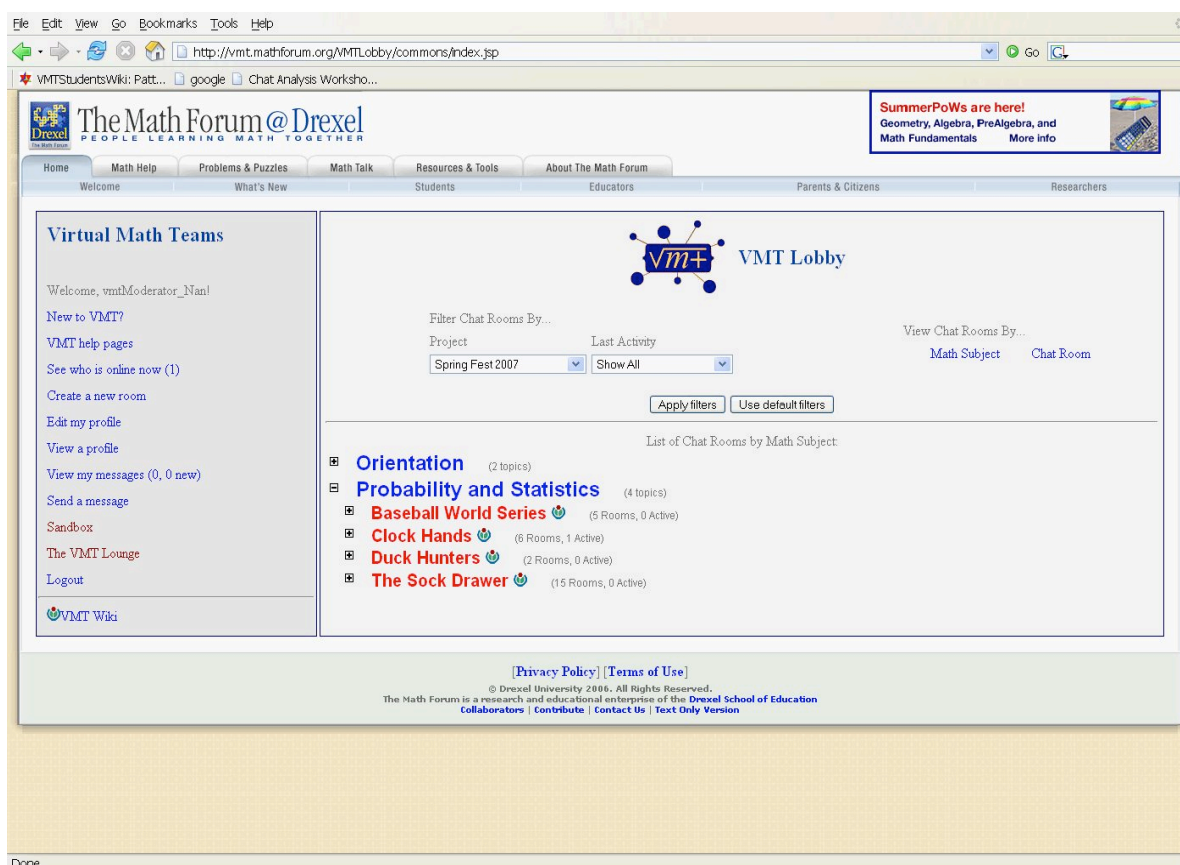


Figure 3.1.1: The VMT Lobby

⁴ The list of ongoing sessions can be viewed at <http://vmt.mathforum.org/vmtChat/vmtRoomList.jsp>.

A chat room of the newest version of VMT Chat looks like this (in Figure 3.1.2), which roughly consist of two parts: a chat space on the right side that supports synchronous chat interaction and a shared whiteboard on the left. It is “shared” in the sense that it looks the same for all the participants present in the room for that any drawing on the whiteboard will appear on all other participants’ screen as well. The shared whiteboard provides a set of drawing tools that allow participants to create drawing such as geometric shapes or free hand objects, or text boxes. The whiteboard keeps the activities that have ever taken place in the history. On the very left of the whiteboard area, there is a bar called “whiteboard history scrollbar”. Dragging the bar allows the whiteboard display to jump to a particular point of time in the history of the evolution of the activities. Only when it is scrolled all the way to the bottom that is the whiteboard at the current state under which activities on the whiteboard are allowed to be performed. The environment offers the display of awareness information that informs users the current activities of others (at the bottom of the typing area) such as who is typing or who erases message as well as what the latest action on the whiteboard is and by whom it is performed (on the vertical left edge of whiteboard).

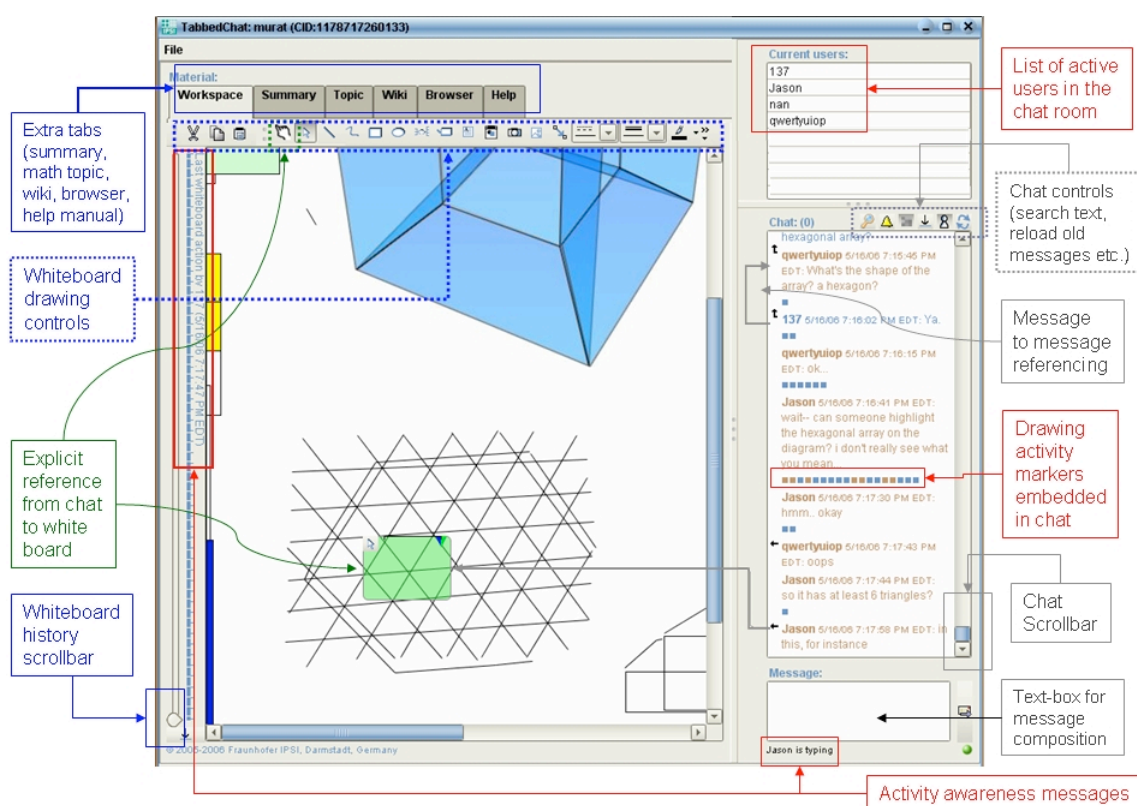


Figure 3.1.2: The VMT Chat Environment (as of Spring 2007, courtesy to Murat Cakir)

Other more sophisticated features in the system include the explicit referencing function (Mühlpfordt & Wessner, 2005; Mühlpfordt & Stahl, 2007) that allow explicit reference (i.e. pointing) either to chat posting (a particular one or multiple, or a specific part of one posting) or to object(s) (or part of object) on the whiteboard (see Figure 3.1.3

and 3.1.4). Another awareness feature was introduced about half way into the Spring Festival in 2006, which is designed to provide awareness information of current ongoing activities on the whiteboard in the chat area by the appearance of little color-coded squares. One square indicates one action performed on the whiteboard and the color matches the color of the chat posting designated to a particular interactant. Mouse-over a square will display information on what action it marks, for example, “qwertyiop resized some objects” (see Figure 3.1.5). Clicking on the square brings the whiteboard status to the current status when the action is being performed.

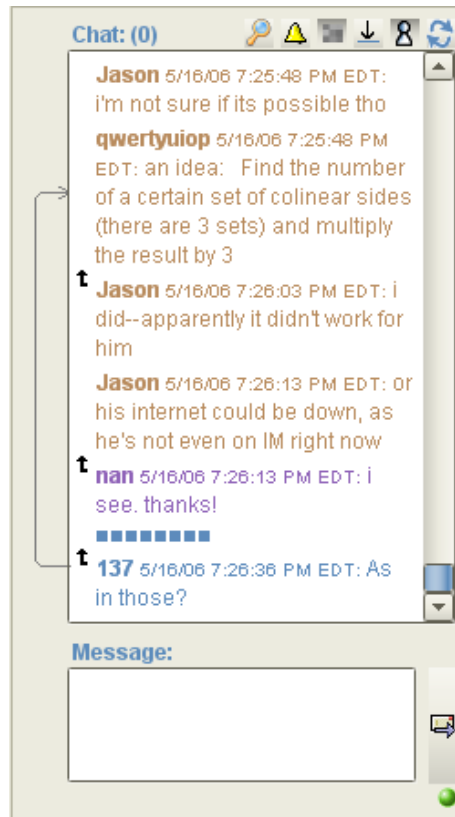


Figure 3.1.3: A message-to-message reference

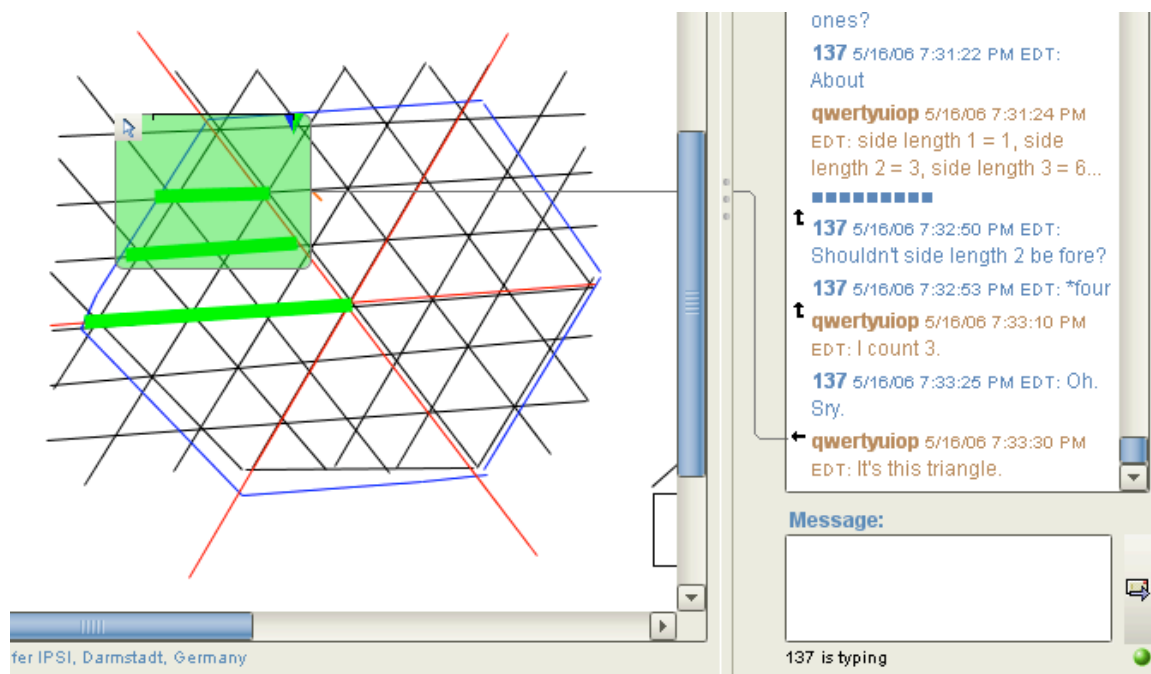


Figure 3.1.4: A message-to-whiteboard reference

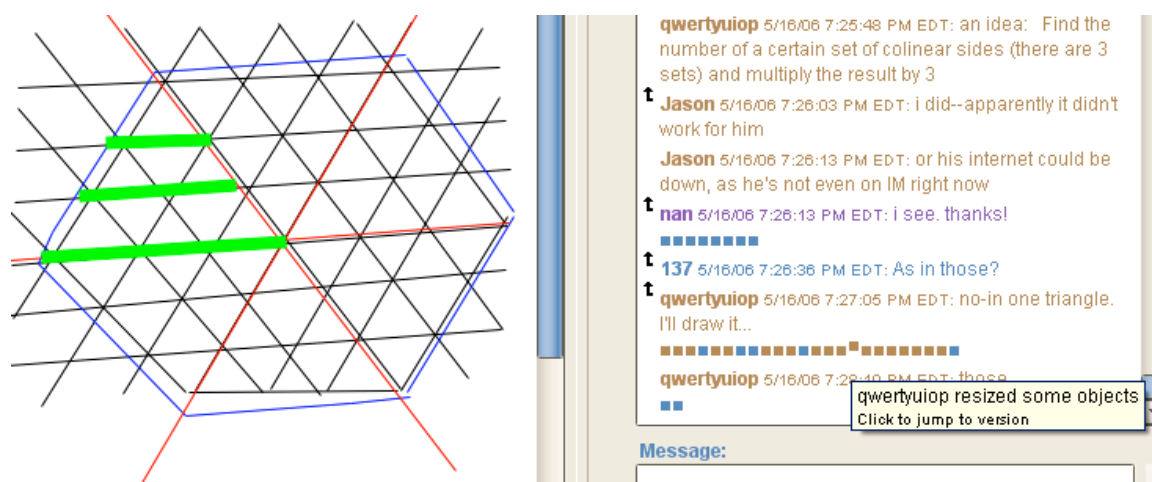


Figure 3.1.5: Awareness information of whiteboard activities in chat area

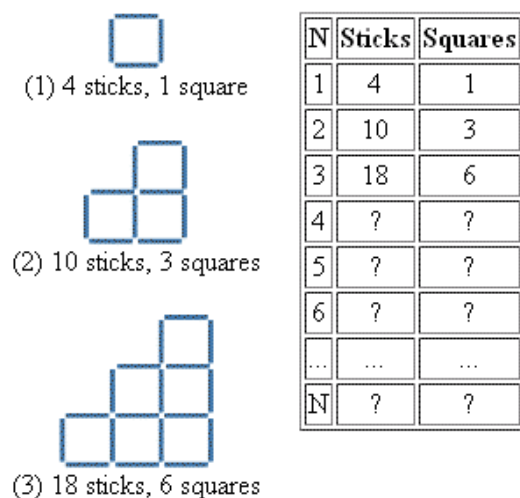
3.2. Data

Majority of the data excerpts for which we present our analysis in this dissertation work are taken from the sessions of Spring Festival 2006 at VMT of two teams (out of the total of five teams), namely, Team B and Team C. The Spring Festival is an annual event that the VMT has been organizing during the period from 2005 to 2007, where groups of students ranging from upper middle school and high school are recruited for participating in 4 consecutive sessions over the period of two weeks. The teams are given the same problems designed by researchers at VMT. Each team is provided with a dedicated chat room as we have seen earlier (Figure 3.1.2). For each session, a facilitator

(either a researcher or a staff from the Math Forum) is present the whole time to give them general instructions of the session as well as serve to provide intervention of their interaction when considered necessary. Instructions given to participants at the beginning of the first session include explaining what their tasks are and what they are supposed to do. It is made explicit to them that they are supposed to work together to solve the problem and they need to make sure everybody understand it. They are also encouraged to summarize their work and share across groups. As part of the design of the experiences at VMT, we also provided mentoring service that includes providing feedbacks to every group after each session, some interventions from the facilitator such as get them explain to each other, summarize their work, or post their findings on the wiki. The VMT wiki has been introduced to the environment as a space for groups to share their work and resources as a way of engaging students in knowledge building. The problem description that is given to the four teams for them to work on reads like the following:

VMT Spring Fest

Here are the first few examples of a particular pattern or sequence, which is made using sticks to form connected squares:



Scroll down to see instructions for each Session.

Session I

1. Draw the pattern for $N=4$, $N=5$, and $N=6$ in the whiteboard. Discuss as a group: How does the graphic pattern grow?
2. Fill in the cells of the table for sticks and squares in rows $N=4$, $N=5$, and $N=6$. Once you agree on these results, post them on the VMT Wiki
3. Can your group see a pattern of growth for the number of sticks and squares? When you are ready, post your ideas about the pattern of growth on the [VMT Wiki](#).

Sessions II and III

1. Discuss the feedback that you received about your previous session.
2. **WHAT IF?** Mathematicians do not just solve other people's problems - they also explore little worlds of patterns that they define and find interesting. Think about other mathematical problems related to the problem with the sticks. For instance, consider other arrangements of squares in addition to the triangle arrangement (diamond, cross, etc.). **What if** instead of squares you use other polygons like triangles, hexagons, etc.? Which polygons work well for building patterns like this? How about 3-D figures, like cubes with edges, sides and cubes? What are the different methods (induction, series, recursion, graphing, tables, etc.) you can use to analyze these different patterns?
3. Go to the [VMT Wiki](#) and share the most interesting math problems that your group chose to work on.

Figure 3.2.1: Task description for Spring Fest 2006

The transcripts of participants' conversations in the chat, together with the history of a shared whiteboard, are preserved in the system for later access or future analysis. The data collected from all the VMT sessions summarized in Table 3.1.1 provides a rich data set for our proposed study. Apart from the transcripts and activities recorded in the system that take the form of html text or spreadsheet, we also have a software tool called session *replayer* (see Figure 3.2.2) that has been developed specifically to support analysts' work. It allows researchers to reply a whole session in a real time manner just as how the interaction takes place and unfolds when the session was conducted, almost identical to what each participant in the session sees at the time, of course except that the display of color scheme for each interactant appears different for individual participant and one could monitor his or her own production of a message or drawing actions. The replayer allows analysts to re-construct the sequentially unfolding interactions and examine the data in real time. The data captured the interactions taking place in the environment in a relatively truthful way since participants rely on the system to communicate and all they made publicly visible to other interactants are also available to us as researchers. With the help of the replayer, we can in a sense re-create the session in real time and observe the interactions just like what participants experienced. The tool also provides functions that allow researchers to play the session at the pace of real time or a faster pace (i.e. certain number times of the original speed). Users can also pause the ongoing session being played or jump to any chosen point of the session by dragging the slider to the designated point. This of course includes jumping back to a certain point freely therefore allows researchers to replay any selected episode repeatedly if needed to thus get full access to the details of interaction available, such as the elapse between two actions, typing and erasing activities that have happened before a message actually gets posted in the chat, etc.

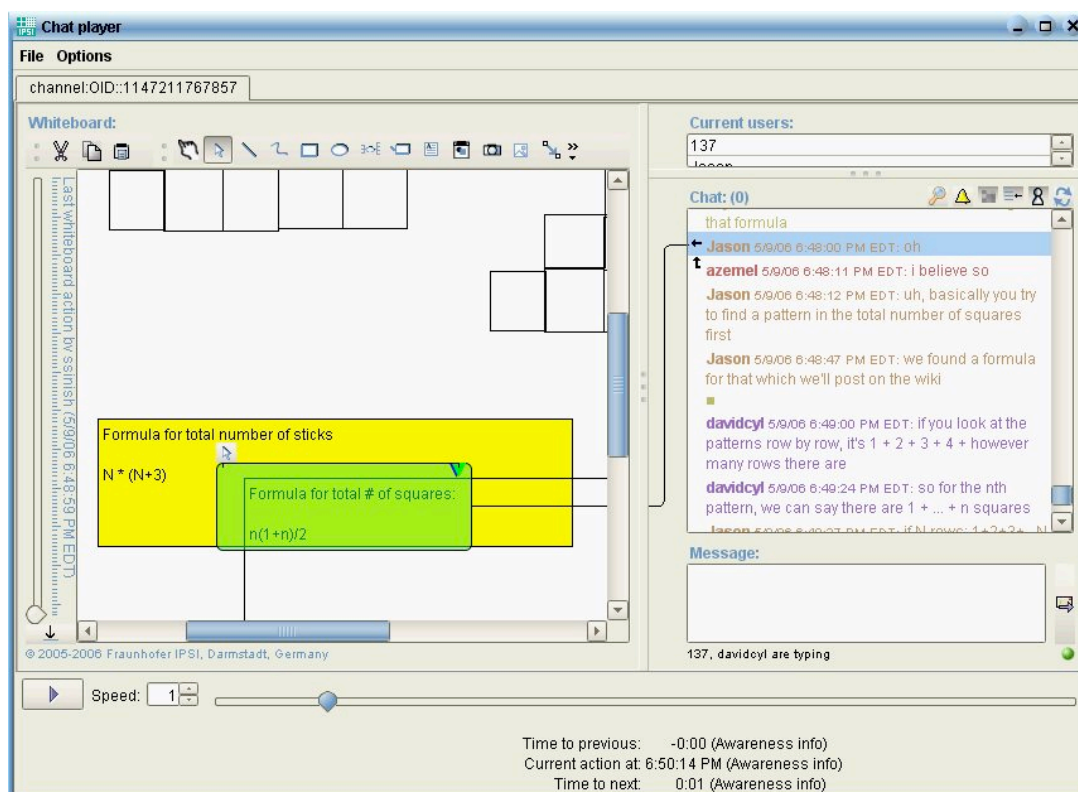


Figure 3.2.2: The VMT Replayer

Only a few excerpts for analysis are taken from transcripts of sessions from the Spring Festival 2005 or those were held in the early stage of the project in 2004 which were conducted on AOL Instant Messenger. They include some example excerpts in our problem statement (Section 1.2) and one in the findings' chapter (Chapter 4) – excerpt 4.3.4 for analysis of pursuing explanation through report. The particular selection and presentation of data excerpts for analysis in this dissertation work are aligned with the development and evolution of this line of inquiry along with the timeline of the project. The research questions that this dissertation work is set to answer arise from our effort in understanding the small group interaction as one of the research issues in our Design-Based Research agenda at the VMT project. We started with analyzing the AOL Instant Messenger data and gradually moved to the data from Spring Festival 2005 as the project proceeded and entered into the next cycle of design. Preliminary and exploratory analytical work conducted using data from those earlier sessions have been reported elsewhere in research papers, posters and reports, which have in fact led to defining our research questions. With the development of the VMT project, we have successfully held the second Spring Festival in 2006 where the event has been structured and designed better drawing from our prior experiences. The design change of the environment including the introduction of new features (such as the display of awareness information of whiteboard activities in the chat area) in an effort to support collaborative math problem solving has deeply shaped the ways that interactions take place in the environment. The development of the replayer software has greatly empowered us as researchers and analysts to have more full access to the interactions in a real time manner and allow

closer look into the process. Spring Festival 2006 has generated a rich set of data for us to analyze and understand. We have chosen to focus our analysis on this set of data both for the need of the project at the time as well as for the aforementioned reasons. Although the research findings we report here are mainly using data from the sessions of two teams from Spring Festival 2006, it is not to forget that they are built upon more preliminary analysis on earlier data as accumulative work at the VMT.

3.3. Research methods

It is believed that the goal for CSCL design is “to create artifacts, activities and environments that enhance the practices of group meaning making” (Stahl, Koschmann & Suthers, 2006). And the design must be coupled with analysis of the practices of meaning construction emerged in group interactions. A design-based research approach (DBR) has been employed at VMT, making use of the findings derived from detailed analysis of group information behavior to propose design suggestions for the VMT environment. DBR is a recently emerging approach for engaging in theoretical research in realistic learning settings. It acknowledges the fundamentally applied nature of educational research (The Design Based Research Collective). The iterative nature of such approach provides opportunities for us to examine the phenomenon of our interest at different stages of the design and possibly draw some comparisons to understand how the specific design of environment or experiment may affect the practices taking place within the setting. For example, earlier design of the VMT environment does not provide any particular information resources on mathematics for the teams engaged in math problem solving. We have observed that from time to time when facing some troubles of understanding arising from knowledge deficit, participants turn to some online resources, for example, to look up a math concept or to look for existing approaches to the problems. Such information is brought back to the group by one participant and shared with others in a variety of ways such as presenting a direct quote taken from the resource, giving a hyperlink to the online resource, or providing this person’s own account of his/her understanding of the information. There are also different ways observed that participants use to do such sharing of resource relevant to their problem solving, such as using particular functionalities in the system, for example, reproducing the text description in the chat area or creating a textbox that contains the resource on the shared whiteboard. Each of those ways of engaging the activity may be quite consequential on the organization of participation and the participants’ engagement in the collaborative knowledge building therefore need closer examination and analysis. One example of how understanding practices inform our design is that after recognizing this interactional phenomenon of “information sharing”, we came to the idea of designing an integrated environment that provides a collection of math resources specifically calibrated for their problems at hand (in this case, the probability problems) in their shared work space. One important interactional feature of the design is that the resource is shared, which means participants could highlight any part of the collection, which will be visible to the group, or make explicit reference to it from the chat.

Discourse of students engaged in learning activities is increasingly recognized as of central importance to science and math learning by the learning sciences community.

Studying the practices relevant to understanding work that participants do as a group at VMT requires a methodology that can allow us to look into the processes and interactions (Dillenbourg et al., 1995; Stahl, Koschmann, & Suthers, 2006; Koschmann, Stahl, & Zemel, 2007). We have adopted an approach informed by ethnomethodology and conversation analysis to study the online interactions of small groups that consist of both “conversations” in the form of exchange of chat postings and activities in the system including actions performed on the shared whiteboard, referencing actions, and so on.

3.3.1. Ethnomethodology and Conversation Analysis (EM/CA)

Funded by Harold Garfinkel (1967), ethnomethodology studies the routine ways by which actions are performed to constitute the intersubjective reality of social life. It emerges from the revolution to the prevailing cognitive approach in social sciences and offers a procedural approach to some central topics of sociology, including the theory of social interaction, the nature of intersubjectivity, and the social constitution of knowledge. These conceptual issues have been traditionally approached by the Parsonian theory of action (Parsons, 1937) which is essentially a theory of the motivation of action, derived from Durkheim. It proposes that the ends of action and the means by which the ends are sought are subjected to the powerful influence by moral values, which are internalized during the course of social interaction. Ethnomethodology has sought to separate the theory of action from motivations and focus on how social actions recognize, produce and reproduce social actions and social structures. Drawing extensively on the work of Alfred Schutz’s (1932/1967) phenomenological analysis of intersubjectivity, Garfinkel proposes the study of properties of practical common-sense reasoning in mundane situations of action for sociological analysis. Similar to the phenomenological procedure (Psathas, 1980; Schutz, 1962b), ethnomethodological approach stresses on studying how participants create, assemble, produce and reproduce the social structure to which they orient instead of beginning with a privileged version of the social structure to which analysts treat the participants as oriented. In other words, analysts refrain from imposing any predefined structure to the phenomenon of analysis. This is called “ethnomethodological indifference” (Garfinkel & Sacks, 1970). Ethnomethodology thus replaces the prevailing motivational approach with a procedural approach that embodies the proposal that “the activities whereby members produce and manage settings of organized everyday affairs are identical with members’ procedures for making those settings ‘accountable’” (Garfinkel: 1984a, p.1).

Through Garfinkel’s well-known breach experiments with games and in real settings, it is conjectured that all actions as perceived events may have a constitutive structure. The observations made from the experiments imply that social actions can be subjected to detailed structural analysis if their constitutive structures are visible in the organization of action itself. Such way of analyzing actions is not about the motivations but on the procedural bases through which they are produced and understood.

Another process proposed by Garfinkel that is implicated in the interpretation of actions is called “the documentary method of interpretation”:

“the method consists of treating an actual appearance as ‘the document of’, as ‘pointing to’, as ‘standing on behalf of’ a presupposed underlying pattern. Not only is

the underlying pattern derived from its individual documentary evidences, but the individual documentary evidences, in their turn, are interpreted on the basis of ‘what is known’ about the underlying pattern. Each is used to elaborate the other.” (Garfinkel: 1984c, p. 78)

This identifies a general process of understanding. Through the study in the context of a form of counseling that was designed to exaggerate such method’s features, it is demonstrated that participants in any situation of action apply a set of interpretative procedures which they use, largely unconsciously, to determine a specific sense for particular, located social actions. When such sense cannot be achieved, participants may not necessarily abandon their understanding. Rather, they use the same procedural bases as grounds to judge actions as departures from ‘normal sensible’ behavior. Such “doubly constitutive” procedures provide intelligibility of perceived normal behavior and for the visibility of action that deviates from this. These constitute one of the central assumptions of ethnomethodological analytic work that “meaningful conduct is produced and understood based on shared procedures or methods (Heritage, 1988)”.

Harvey Sacks (1974), who worked closely with Garfinkel, developed a similar methodological approach for the close analysis of ordinary *talk-in-interaction* together with Schegloff and Jefferson and called it conversation analysis. Conversation Analysis (CA) is the study of how “society” is achieved through the local production of interaction, including talk. It studies “the order/organization/orderliness of social action, particularly those social actions that are located in everyday interaction, in discursive practices, in the savings/tellings/doings of members of society” (Psathas, 1995, p.2). As a vigorous and distinctive aspect of ethnomethodology, CA analyses, like other ethnomethodological studies, focus on the methods or procedures by which social actors or participants recognize, produce and organize their actions as intelligible. “The core analytic object is to illuminate how actions, events, objects, etc., are produced and understood rather than how language and talk are organized as analytically separable phenomena.” (Pomerantz & Fehr, 1997, p.65). distinct from discourse analysis, sequential organization

Even though CA stresses starting the analysis from the data at hand and not from any preconceived ideas about what the data “are” or “represent” (ten Half, 1999), there is conceptual apparatus built up in the field over time to provide us a general perspective on conversational data. The CA research has identified conventional structures of face-to-face interaction and methods as used by participants that enable participants to produce meaningful social orders, e.g. adjacency pairs, turn-taking mechanism, insertion sequence, repair, preference structure, etc (Sacks, Schegloff & Jefferson, 1974; Schegloff, Jefferson & Sacks, 1977; Schegloff, 1988; Schegloff, 2006). Indeed, Schegloff’s recent analyses (as in 1992a, 1996a, 1996b) are evidently based on cumulative insights and findings. We can use those basic concepts from the CA tradition to structure our ‘looking’ at the data.

In more recent years, conversation analysts have also examined quasi-synchronous computer-mediated communication (or in other words, online chats) (Garcia & Jacobs, 1998; 1999). They outlined significant differences between online chats and face-to-face interaction as speech exchange systems, including differences in turn-taking organization, consequential differences for participants between utterance production and message production, differences in production and organization of repair, etc. It is well known that in an online chat environment like this where more than two participants are interacting, the turn-taking rules for face-to-face interaction with dyads do not apply directly (Garcia

& Jacobs, 1999). The characteristics of different “turn-taking” mechanism can result in confusion both for participants and researchers when examining the sequence of postings in chat (Herring, 1999).

The works in both CA and ethnomethodology have laid out a methodological framework for our study. For us as researchers, methods based on conversation analysis can be used to make visible the process of group meaning making mediated by artifacts provided in the environment. We have applied an approach that combines aspects of *conversation analysis* and *ethnomethodology* to analyze the conversation transcript of participants’ interactions, coupled with analysis of their use of the functionalities provided by the system. This approach stresses close examination of interactional data in data sessions, to identify and describe the observable methods participants use to make sense of their interactions for themselves and each other.

3.3.2. Procedure of data analysis

Aligned with its ethnomethodological nature, CA is committed to “unmotivated looking”, a research orientation that analysts take. When conducting their analytical work, analysts do not start with research questions like most studies do. Instead, analysts begin their examination of the data without any prescribed idea or understanding of what is going on and notice interesting features of the interaction taking place. Emanuel Schegloff (1996b) has provided a useful explication of the idea of ‘unmotivated looking’:

Virtually all of these results emerge from an ‘unmotivated’ examination of naturally occurring interactional materials – that is, an examination not prompted by prespecified analytic goals [...], but by ‘noticings’ of initially unremarkable features of talk or of other conduct. The trajectory of such analyses may begin with a noticing of the action being done and be pursued by specifying what about the talk or other conduct – in its context – serves as the practice for accomplishing that action. Or it may begin [...] with the noticing of some feature of the talk and be pursued by asking what – if anything – such a practice of talking has as its outcome. (Schegloff, 1996b: 172)

We set out with looking at our data without particular questions in mind. Through some preliminary analysis we did together in our data sessions, we have come to notice that participants often face problematic situations where understanding has emerged to be troublesome that they need to manage. Those situations seem to be of importance to their problem solving activities since those are often occasions where understanding work is done together thus provide us opportunities to look into the processes of collaboration and “learning”. From there we have gradually defined the phenomenon of our interest and formulated our research questions to guide our analysis.

We quote Heritage’s summary of CA’s approach to data here to demonstrate the method we use in pursuing our proposed inquiry:

Once possessed of a corpus of data, CA operates in the first instance using inductive search procedures. An analyst who is interested, for example, in how invitations are accepted or rejected will begin by building up a collection of invitations and will attempt to establish regularities in the organization of positive and negative responses to them. At the core of this task is the demonstration that

these regularities are methodically produced and oriented to by the participants as normative organizations of action. (Heritage, 1988:131)

Some researchers describe CA's approach to data as "analytic induction", a concept that is described as follows in Ragin's discussion making distinction of qualitative social research:

Analytical induction is a technique used primarily by qualitative researchers to access commonalities across a number of cases and thereby clarify empirical categories and the concepts that are exemplified by the cases included in a category. It is a 'double fitting' of ideas and evidence that focuses on similarities across a limited number of cases studied in depth. (Ragin, 1994:183)

There are a set of rigorous procedures and subsequent steps that conversation analysts follow in their analytical process. Schegloff mentions "three distinct elements" that should be present in an empirical account of "the action that some utterance implements". These are strong requirements for an analysis to meet:

1. 'a formulation of what action or actions are being accomplished';
2. 'a grounding of this formulation in the "reality" of the participants';
3. an explication of how a particular practice, i.e. an utterance or conduct, can yield a particular, recognizable action. (ibid)

We have followed a set of rigorous procedures prescribed by CA in doing our data analysis. First we select excerpts from the transcript (including chat and activities conducted on the shared whiteboard) of our particular research interest. The second step is that we ask the question "What's going on here?". CA data analysis techniques requires researchers when they come up with an answer to this question that makes sense to them, ask "What particular actions of the participations in the interaction provide a basis for coming up with the answer to 'what's going on here?'". CA requires analysts not consider "intention" and "motivation" as ways of analytically accounting for action. Instead, analysts are only looking for those publicly available and demonstrable features of interaction that allow them to make those inferences (Zemel, 2004, Syllabus of CA Seminar at VMT).

Schegloff proposed a preparatory analytic routine in three steps (in a 'Didactic Seminar' given at the American Sociological Association meetings in San Francisco, August 1989):

1. check the episode carefully in terms of turn-taking: the construction of turns, pauses, overlaps, etc.; make notes of any remarkable phenomena, especially on any 'disturbances' in the fluent working of the turn-taking system.
2. then look for sequences in the episode under review, especially adjacency pairs and their sequels.
3. and finally, note any phenomena of repair, such as repair initiators, actual repairs, etc.

Using these requirements and procedures as our guidelines, we also have structured our steps in approaching the data following a set of tools formulated by Anita Pomerantz and B.J. Fehr (1997: 71-4). These tools are offered to be applied subsequently to help develop conversation analytic skills, which consists of 'questions to ask and areas to think about'.

1. Select a sequence.
2. Characterize the actions in the sequence.
3. Consider how the speakers' packaging of actions, including their selection of reference terms, provides for certain understandings of the actions performed and the matters talked about. Consider the options for the recipient that are set up by that packaging. (The notion of 'packaging' refers to the form chosen to produce the action.)
4. Consider how the timing and taking of turns provide for certain understanding of the actions and the matters talked about.
5. Consider how the ways the actions were accomplished implicate certain identities, roles and/or relationships for the interactants. (adapted from ten Half, 1999)

Data sessions are important venues for researchers at VMT to look at data excerpts closely together and conduct analysis collaboratively with hearing other people's perspective and take on the features they see in the interaction. It is a way to prevent subjective interpretation and inferences of what may be going on in the interaction and minimize idiosyncratic analyses. Data sessions have been held weekly at VMT for over 3 years where we as researchers and analysts did our analytical work in a close group and shared our thoughts and built shared meaning of what the data we were examining may tell us on our research questions.

Here we summarize the methodological commitments we have made to guide our analytic inquiry:

1. **Qualitative study:** The study will be qualitative, exploratory and descriptive. We will not formulate hypothesis to guide our inquiry. Instead, we are taking an analytical approach from an interactional perspective.
2. **Participant needs:** We try to determine the participants' own concerns, interests and relevancies in interpreting the log data by analyzing how they co-construct items through their interactions. We try to avoid imposing *a priori* analytic categories, such as theoretical concepts, model categories or pre-existing coding schemes.
3. **Inquiry:** We treat information as an emergent observable outcome of interaction, as it arises from certain kinds of inquiries. We are less interested in analyzing cases in which information is treated as a fixed object or existing fact.
4. **Sense making:** We are investigating the interactions that are observable and reportable in the log data. We are not investigating individual psychological states of mind, except as displayed in the log data. We are not conducting surveys, interviews, think-aloud protocols, pre/post-test comparisons or statistical correlations to get at mental representations that might operate behind the interactions. These are not feasible in the VMT online context.
5. **Virtual context:** We are interested in the online context; our findings are not necessarily applicable to face-to-face information interactions and behaviors. This dissertation is based exclusively on data collected in the online Virtual Math Teams (VMT) project.

CHAPTER 4. Findings

4.1. Pose a question – pursuing explanations through questions

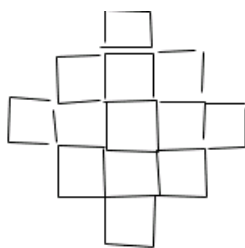
One common way that participants initiate troubles of understanding is to pose a question that elicits information on some math concept to which previous reference has been made, or explanation of or elaboration on the idea or work that has been presented by others. We label such action of posing a question as “doing inquiry” in general. Questions hold the recipient accountable for producing a response (Schegloff, 1968; Heritage, 1988).

4.1.1. Case study 1

In this case study, we show how participants orient themselves to the trouble of understanding as *referential problem* and how inquiries are used to introduce such trouble to the group. An answer is produced and as an outcome of the process, *shared artifacts* of “side length” are constructed and made available as *referential resources*. They become *knowledge artifacts* that are reused later on by one participant to produce an alternative approach for solving the problem. An unattended question is brought up through intervention from a third participant using a different method. The procedure by which the interactions are organized to doing inquires shows an escalation structure, meaning a more direct and explicit method is only used to pursue an answer when a more implicit way of eliciting explanation fails. Our analysis also demonstrates a common procedure in problem solving process when a group deals with troubles: a problematizing move is made after an explanation is produced in response to an inquiry, which subsequently leads production of an account for what is being problematized and as a result, problem is revealed and alternative approaches are offered.

Part I: How the troubles are introduced and attended

The sequence under analysis starts about 30 minutes into the second session of Team C (of four sessions in total across two weeks). Prior to the sequence as shown in the excerpt of its transcript (*Excerpt 4.1.4*), the three participants with screen name 137, qwertyuiop (henceforth “qwer” for the convenience of reference in analysis), and Jason respectively, have together engaged in defining the new problem – “diamonds” – for their current session, first proposed by 137. As a result of the process defining the problem, a representation of the problem (*Figure 4.1.1*) has been constructed on the shared whiteboard by qwer to get assessment from the group. How the problem is defined in the representation is implicitly endorsed by the group. At the beginning of this sequence (see *Excerpt 4.1.4*), three participants present in the session each offers their observations on the pattern of growth in this new problem of “diamonds”, treating the representation as accepted and that working on figuring out the pattern of growth is the next step for the group. The observations are made in three separate posts, which appear only within seconds from each other – suggesting they are produced about the same time as parallel actions. This is also supported by the fact that the time the three participants start composing their posts overlaps with each other as indicated by the awareness information in the system when we play the session in real time using our replayer software.



137 5/11/06 7:54:03 PM EDT: So the number of squares is $n^2 + 4$, where n is a side length

qwertyuiop 5/11/06 7:54:12 PM EDT: the "each square with 2 sides" thing doesn't work as neatly here

Jason 5/11/06 7:54:13 PM EDT: if we look at rows, its 1, 3, 5, 3, 1

Excerpt 4.1.4: proposal of three observations

Figure 4.1.1: the new problem “diamonds”

Among the three observations posted the first is from 137, in which a formula for “the number of squares” is presented. Formulated in the format of a complete mathematical statement, the observation is prefaced by “So”, indicating that what follows, i.e. the statement, is built upon or derived from some prior interactional resources available, presumably the sequential actions in which the “diamonds” problem is defined in qwer’s candidate representation that has received implicit endorsement from the group at this point. While 137’s post offers something that appears as a final result of a problem, the following post from qwer makes connection between the current problem and some shared method of the group referred to as “*the ‘each square with 2 sides’ thing*” by pointing out that applying the method “here” may be problematic. Jason’s offering that appears about the same time as qwer’s however seems to orient the group to the available drawing on the whiteboard and offers an observation of the number of squares in different rows in the “diamond” shape representation of the problem. Offerings like those invite recipients to uptake them in certain ways. For example, one that looks like a final result as in 137’s invites assessment while the other two orient recipients to a particular aspect and invite them to offer something alternative or take a next step building on what’s been offered. Among the competing offerings, 137’s gets selected by both participants, namely qwer and Jason, to respond (*Excerpt 4.1.5*). Instead of making an assessment of 137’s formula that appear as some final result of the problem, both recipients pose inquiry of some sort regarding 137’s statement using explicit referencing. Qwer’s inquiry is formulated in a direct “how” question (at the first line of *Excerpt 4.1.5* at 7:54:28), demanding an explanation of the reasoning process behind “that” – a deictic term that seems to refer to the statement by 137, putting the presenter in the position of producing an account for what’s been presented. In contrast, Jason’s inquiry posted about the same time as qwer’s, is designed as an invitation for co-constructing a sentence. It seems to be designed to elicit some clarification by particularly pointing to “side length” in 137’s statement as the source of trouble.

† **qwertyuiop** 5/11/06 7:54:28 PM EDT: how did you get that?

† **Jason** 5/11/06 7:54:29 PM EDT: by side length you mean...

137 5/11/06 7:54:50 PM EDT: The orange.

**

Jason 5/11/06 7:55:01 PM EDT: 000hh... clever 😊

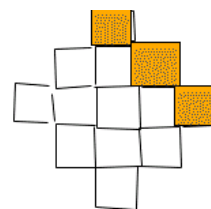



Figure 4.1.2: illustration of “side length”


Excerpt 4.1.5: design of inquiries


It may be worth noticing that in 137's statement, "side length" is introduced to the group for the first time in their shared experiences in the sessions, which is not recognized by us as analysts, probably the participants as well, as an predefined term or existing mathematical concept. However, the way it is being presented seems to suggest that it is treated by the presenter as something predefined and the recipients are expected to know about. Presented with such a term that is not recognizable, participants have different ways to inquire about it, such as posing a direct information question "what is a side length?" or making a self report "I don't understand what 'side length' means.", which under circumstances may convey a lower epistemic stance of the questioner or reporter on the matter being inquired about. Jason's inquiry as we observe here however treats the trouble with "side length" as caused by some *referential problem* as indicated by the use of "you mean". He orients to the trouble as not lying at his side, i.e. caused by differences in epistemic stances but instead at the presenter's, by positioning the presenter as being accountable for explaining the undefined term.


Following the two inquires by qwer and Jason, 137 performs some drawing actions on the diagram of the "diamond" that end up in filling the three squares on the upper right side with orange color (as indicated by the three blue squares following Jason's post). The actions are subsequently followed by a text post "The orange.", which is seemingly referring to what has been produced on the diagram – the three orange squares. The actions and the post are treated as intelligible by one of the inquirer Jason, i.e. a response to his invitation for construction of a sentence on what "side length" means, who offers a positive assessment in the subsequent line. The assessment is prefaced by a rather strong exclamation indicated by "ooohh", an emphasized form for a change-of-state marker "oh" (Heritage, 1998), showing achieved understanding of some sort for some prior actions. By offering such a positive assessment, Jason seems to treat 137's actions as producing an acceptable answer to his inquiry about "side length". What 137 has produced however appears not clear to another participant qwer who subsequently seeks clarification by asking a yes/no question that points back to 137's post "The orange.". After providing affirmation to this yes/no question, 137 orients himself to the whiteboard and starts moving objects around, which results in a cleared work space in the area adjacent to the "diamond" with illustrated "side length". By diverting from attending the inquiries to actions of cleaning up the work space, 137 moves forward to some set-up work for the group's next task, therefore concluding this line of discussion, treating the production of "side length" as adequate explanation for how the formula is derived as well, although the reasoning process is still left unspecified and up to the recipients to figure out. It is also possible that qwer's question that gets posted prior to Jason's simply is not attended to by 137 for reasons that are not apparent to us as analysts.

Part II: intervention of an unattended question and problematizing move



t **qwertyuiop** 5/11/06 7:55:08 PM EDT: is the saide lenght?


137 5/11/06 7:55:28 PM EDT: Yes.


Jason 5/11/06 7:55:52 PM EDT: can you explain how you got that formula?


qwertyuiop 5/11/06 7:55:57 PM EDT: so +4 is just for a side lenaht of 3

It is at this point, about one whole minute later after 137's text post that makes reference to the produced object as an answer to the inquiry about "side length",

that Jason articulates an explicit request (at 7:55:52 in *Excerpt 4.1.6*) directed to 137 (by using “you” and referring to “that formula”) which reformulates qwer’s earlier “how” question that is not explicitly attended. Jason’s request for explanation reveals that the trouble with understanding the presented formula is shared by both participants. The unattended question is intervened by a third participant who reformulates the question into the form of a request. It is therefore interactionally harder to ignore the trouble being introduced since the progressivity of the interactions is breached (Stivers and Robinson, 2006) and needs to be restored when both recipients present share the same trouble with some work presented for assessment. The sequence of the two methods Jason uses to bring his trouble relevant to the ongoing interaction exhibits a structure of “escalation” that we have discussed earlier else where (see Section 4.3.2). We use “escalation” structure of doing an inquiry to refer to a repeatedly occurring pattern of how participants organize their work of doing inquiries. Usually a gentle and less explicit method is used first to make the inquiry regarding some trouble, such as Jason’s early attempt of inviting the proposal presenter to provide more information on “side length”, which is needed in order to understand the proposed formula but not necessarily guarantees the formula can be self-explanatory once “side length” is explained. A more direct method may be used when the first method fails to achieve the attempted effect on addressing the trouble. In our case, when “side length” is explained but the trouble with understanding the presented formula is still not resolved, Jason makes a direct request asking 137 to explain how he got the formula. Inquiring about “side length” also shows that Jason makes effort to understand the formula first with explanation on “side length” provided and only when that turns out not working he requests help from 137.

It is also worth noticing that Jason’s request indicating his trouble understanding the presented formula would not be as difficult to make since the other member (qwer) has already expressed the similar concern earlier. It can be difficult for a participant to reveal his troubles or problems with understanding in a peer group because of the concerns of “losing face” (Goffman, 1967). The risk of “losing face” may be perceived higher if the participant is likely to be the only one with the trouble. The risk is greatly reduced if one knows another member has the same trouble. This sequence of interaction shows an example of how an unattended question has interactional consequences on the ongoing understanding work that the group is engaged in doing.

Qwer, on the other hand, demonstrates his achieved understanding of the presented formula following 137’s explanation for “side length” in an assertion he makes that challenges the validity of the formula (7:55:57). The assertion consists of a “so” prefaced statement and a question mark in an immediately following separate line. The “so” preface indicates that what follows is derived from previous actions, i.e. 137’s production of a response to the presented inquiry about “side length” or inquiries. The subsequent question mark following the statement converts the structure into a yes/no question with an affirmative answer as preferred response (Pomerantz, 1984). Such a question does not seek information but rather conveys information to the hearer (Koshik, 2003), showing a strong epistemic stance the questioner holds regarding the matter at hand. In this case, such structure is used to accomplish *conveying an assertion* that “+4 is just for a side length of 3”. Since a formula in mathematics is commonly understood as generally

applicable to all cases, the assertion challenges the validity of the presented formula since it is “just” for a particular case – a side length of 3. The direct reference of “side length” in qwer’s assertion shows that his assertion is built upon the understanding of “side length” as a result of the prior interactional sequence where an explanation is produced and an artifact of “side length” is constructed as an outcome of the process. Posed in an inquisitive form, qwer’s assertion calls for an agreement. It puts the presenter of the formula accountable for producing an account if a negative answer is provided. The assertion is taken up by Jason later on as such after an insertion sequence where 137 seeks help for using drawing tools for accomplishing some drawing actions. Using explicit referencing to post where the assertion is made, Jason offers a mitigated agreement in which an alternative approach “recursion” is proposed to address the validity issue.

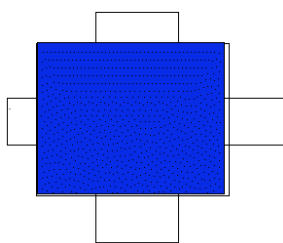


Figure 4.1.3: illustration of 137’s formula

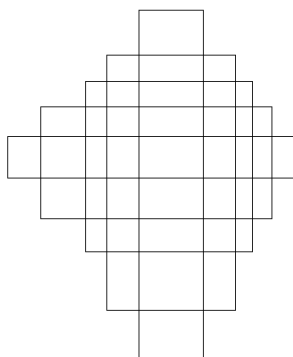


Figure 4.1.4: “diamonds” at a later stage of growth

- 137 5/11/06 8:04:42 PM EDT: So the blue is n^2 and there are 4 more squares outside for each...

- t qwertyuiop 5/11/06 8:05:12 PM EDT: that's number of squares?
 137 5/11/06 8:05:24 PM EDT: IT should be...
 137 5/11/06 8:05:26 PM EDT: shoot.
 *
- t qwertyuiop 5/11/06 8:06:23 PM EDT: or number of sides?
 137 5/11/06 8:06:37 PM EDT: I screwed up somewhere...
 t qwertyuiop 5/11/06 8:06:50 PM EDT: what are you trying to find?
 137 5/11/06 8:07:19 PM EDT: The number of squares.
 Jason 5/11/06 8:07:36 PM EDT: actually... could this be figured out by using some geometric series
- ← Jason 5/11/06 8:08:18 PM EDT: the fact that, when the squares are arranged in a diamond shape result in $1+3+5+3+1$ total squares in the diagram to the left, remind me of pascal's triangle
 Jason 5/11/06 8:08:35 PM EDT: just a thought.. not sure if it'll work
- t qwertyuiop 5/11/06 8:08:35 PM EDT: using your previous method: $SideLength^2 + (SideLength-1)^2$

Excerpt 4.1.7: production of reasoning process & proposal of alternative approaches

Part III: Production of an account for the problematized approach and proposal of alternative approaches

After a long drag of sequence where 137 is trying to produce something on the whiteboard after dealing with technical difficulties and getting the help from others, 137 finally produces some drawing as shown in Figure 4.1.3 and a text post that seems to explain how the original formula is derived with the illustration of the constructed object in the drawing: “So the blue is n^2 and there are 4 more squares outside for each...” (at 8:04:42, Excerpt 4.1.7). It is fairly obvious that “the blue” refers to the blue square in the diagram, which corresponds to the first part of the formula “ n^2 ” and “4 more squares outside for each” refers to those outside the blue square and corresponds to the “+4” part

of the formula. The production of the reasoning behind the formula can be seen as response to the inquiry that has been raised by both qwer and Jason respectively, as well as an account in response to qwer's assertion. The reasoning behind 137's presented formula is finally explicated visible therefore available for examination by others. In the following sequence, 137 continues with some drawing actions on the whiteboard that resemble a similar shape of the diagram with blue square but at a later stage of growth. The intelligibility of the new diagram is also made possible by the available production process on the whiteboard, which is similar to how the first diagram is produced, i.e. by layering rectangles on each other to grow the pattern. It is upon the completion of the second diagram for the grown "diamonds" at a later stage that 137 articulates that there is problem with his method: "shoot." and "I screwed up somewhere....". Analyzing the sequential production and timing of those actions seems to show that the production of an account of the presented formula in response to the assertion that problematizes the validity of the formula, makes the reasoning process visible therefore leads the presenter and the subsequent account producer to realize the problem with the approach used to derive the presented work.

137's articulation that his presented work is problematic is immediately taken up by both recipients. Jason offers an alternative approach of "using some geometric series" for the group to consider, elaborated with his observation on the patterns of squares in the diamond shape as reasoning. Qwer, on the other hand, offers a formula for "the number of squares" that makes use of "side length", which he refers to as a method and explicitly attributes its authorship to 137 – "using your previous method". The meaning of qwer's post is accomplished through the use of explicit referencing to 137's previous post "The number of squares", deictic reference "yours" (meaning the referent, 137's), and direct reference of "SideLength" in the formula.

4.1.2. Case study 2

Asking an appropriate question as a way of introducing one's trouble requires certain competency of the questioner to express the "unknown" and convey to the recipients what the trouble is and how the trouble could be addressed. When a participant is not competent enough to pose such a question, or not competent to recognize what kind of trouble it might be, one may not be inclined to ask a direct question which is considered by the participant as risking losing "face". In our second case study, we show a case where participants orient to the trouble as *referential problem* as well, i.e. as caused by the use of an undefined term by the presenter, but the methods participants use to do inquiries on the troublesome matter are quite different from what we see in the first case. Our analysis shows how an inquiry for the same trouble shared by two participants is *co-constructed* by an *intervention* to a "failed" question. Following the question-response sequence, *demonstration of achieved understanding* is offered for the assessment of the local expert – the presenter. A similar *escalation structure* is observed on how the sequence of doing an inquiry is organized. Similarly, *shared artifacts* – the "hexagonal array" – are constructed and become *shared referential resources*, which are used later on in next steps of their problem solving trajectory.

Part I: how the trouble with “hexagonal array” is introduced

The production of the “diagram” is complete as marked by qwer’s post “triangles are done”. The “diagram” is presumably of the relevance to the problem that the group will be engaged in defining and eventually developing solutions to. Our analysis starts from the sequence that takes place after the “triangles are done” by qwer at 7:14:51. We have chosen the next post by 137 (at 7:15:08) as the beginning of the sequence because from preliminary analysis of the interaction it seems to be where the prior sequence of actions of creating “a diagram of a bunch of triangles” has ended and a proposal is made with regard to the produced diagram for the group to consider, which is a beginning of a different set of interactions organized around the proposal. The proposal reads as follows – 137: *So do you want to first calculate the number of triangles in a hexagonal array?*

Starting with “So”, 137’s post concludes the prior actions of producing “a diagram of a bunch of triangles” as complete, makes them relevant to the current ongoing interaction, and projects the next thing for the group to do as one step that is to be followed by other steps – “to *first* calculate the number of triangles in a hexagonal array”. Considering the task that the group is engaged in doing is to “discover” problems themselves and try to solve them, we were expecting to see the group would define their problem first like what they did last session. In the previous session, 137 makes a proposal of a problem of “diamond” shape made of squares: “Let’s try diamonds first..” (7:50:07), which was subsequently defined by the drawing of “diamond” shape by him and qwer. However in this drag of interactions from the beginning of session to now, we have not observed the work of *explicitly* defining a problem. Instead, a proposal is made by 137 in regards to a task for the group as a collective to do as if the problem has been defined and made available to the group through the drawing actions involved in producing a “grid” of triangles. It is rather left implicit what the problem is for them. The initiator of the drawing and also the proposal maker, 137, seems to assume certain competence of his peers and the “problem” should have become intelligible and recognizable for them as of now.

It is the first time that “*hexagonal array*” appears in the sessions of the group. It is a term not recognizable by us, as analysts, and possibly neither by the participants, as a particular, predefined term or concept in math. Nevertheless, by including it in a proposal of task for the group to do, 137’s post seems to treat it as something known thus recognizable by its recipients. “*the number of triangles*” in the proposal is quite clearly referring to the diagram that has just been completed by qwer, as requested by 137 as a repair to his “failed” attempt for creating such a diagram. Although at the beginning, 137 did start with drawing lines resembling a hexagon shape, which was further divided by a bunch of parallel lines within, the drawing on display on the shared whiteboard at the moment is merely “a grid” of triangles. Therefore “hexagonal array” seems to be referring to something that *yet to be constructed* for the participants. The proposal assumes the relevance of “hexagonal array” and the diagram made of triangles, which seems to be the source of trouble for the recipients’ understanding of the proposal that is produced subsequently. The trouble caused by the referential problem from using the term “hexagonal array” in the proposal is observed in the immediately following interactions where both qwer and Jason use different ways to introduce the trouble.

t 5/16/06 7:15:02 PM EDT: do you want to calculate the number
 of tr
 t qwr Excerpt 4.1.8: Hexagonal shape of the array? a
 hexagon?
 t 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 don't really see what you mean...

A proposal as in the first line of the transcript calls for acceptance or rejection. To be in a position of being able to make such decision requires that recipients have “adequate” understanding of the proposal in order to do so. In anticipating or seeing potential troubles of understanding the proposal, the proposal maker may choose to elaborate on it. In response to lack of uptake for the proposal, the proposal maker may also choose to explicitly elicit such assessment from the group, for example, by posing a question that demands an answer as implicative (Schegloff, 1972, 2006), or a direct request that calls for a response. On the other hand, its recipients could choose to ask questions when facing troubles of understanding, such as to clarify something in the proposal. In this case, the next post appears almost 40 seconds later, a rather noticeable time elapse in a live chat like this, where qwer poses a question: “*What’s the shape of the array?*” that is immediately followed by an offering of a candidate answer “*a hexagon?*” in the same posting (at 7:15:45).

In the interval of 40 seconds or so, no observable activity happens in the chat environment, except the awareness information (which we observe from the real time unfolding of the interactions reconstructed by the replayer software) shows that 137 started typing and then stopped (which means that what’s been composed is erased and does not get posted to the chat), followed by facilitator nan typing and erasing, before qwer started typing, which eventually turned into the posted message at the second line of post (7:15:45). The silence between the proposal and next post indicates there may be interactional troubles of some sort. The proposal is not getting uptake actions as it is designed to receive from its recipients, qwer and Jason. During this period, the proposal maker 137 has had the chance to offer an elaboration on what he has proposed for the group to do or the other participant Jason could have taken up the proposal in whatever way. However, those actions did not happen. The next post by qwer seems quite clearly being addressed to the proposal maker, as indicated by the explicit reference used to point to immediately preceding post where proposal is made, as well as the reference to the terms in the proposal, i.e. “array” and “hexagon”. The question changes the “floor” holding of the interactions in terms of whose turn it is to “speak” next (Sacks, Schegloff, & Jefferson, 1974): the recipients of the proposal are no longer in the position to accept or reject the proposal in the next move but it is now for 137 to respond to the question.

Qwer’s question introduces “a hexagonal array” as a problematic matter by inquiring about “the shape of the array”, which is supplemented immediately with a candidate answer “*a hexagon?*” in the same post. Together, the post seems to be designed to elicit a yes/no answer as for evaluating the candidate answer provided to the “what” question. But is this what the question does here? If the question were asking whether the shape of the “array” – with reference to “hexagonal array”, is “a hexagon”, a yes/no answer to it would hardly add any information to what has been made available in the proposal already. There is some other work the question is doing here.

Although as we have pointed out earlier in the analysis that the lack of referent for “hexagonal array” in the proposal may cause trouble for the recipients, we notice here that the design of qwer’s question seems to treat “hexagonal array” as a predefined recognizable math concept (or accept how it is being used as such by the proposal maker). In mathematics, “array” refers to an arrangement of a set of numbers in rows and columns. According to the generally accepted mathematical understanding of “array”, it does not have a feature as “shape”. The fact that qwer’s question refers to the “shape” of the array is probably based on the “invention” of the proposal maker who made of the first use of “hexagonal array”. In other similar cases we have observed where troubles are caused by some referential problem and recognized by participants as such, a straightforward question such as “what do you mean by X (*the term with referential problem*)?” is posed (see analysis on trouble of “overlaps” in *Section 4.2.2*) or a candidate understanding of the term is offered for assessment that at the same time provides instructions on constructing an expected explanation (see analysis of the sequence on resolving the trouble concerning “colinear sides” in *Section 4.1.3 Episode 2*). From our analysis, we have come to notice that troubles caused by referential problems and treated by participants as such are usually introduced using different methods than those caused by epistemic differences and recognized by participants as such. In the cases where participants recognize the epistemic differences among themselves such as when one does not have adequate understanding of a math concept introduced by another but still need to deal with, asking a question can be a delicate matter for it may pose potential threat to the peer relationship among members of the group.

We also know that it can be rather difficult for some one who has trouble understanding something being brought up to ask a question, since being able to ask an *appropriate* question also requires the competency of the questioner for doing so, which she or he may not have yet. Facing such a situation, participants turn to various interactional methods to introduce their troubles or problems of understanding as relevant to the interaction. Among those methods, one is to articulate what one knows as a way to elicit more information on what one does not but wants to know. Such method could also be used at the same time to manage face issues, especially in a peer group, avoiding the risk of “losing face” by asking a question that may reveal the ignorance of the questioner (Goffman, 1967). When such method is used by the questioner, it is for the recipient of the question, i.e. the presenter of the statement that originates the source of trouble, to detect what the questioner may be really asking and provide elaboration or more information on what’s been inquired about. By posing a question (with a candidate answer) the answer to which would not add more information to what’s already known, the questioner qwer is signaling that he has trouble understanding “hexagonal array” and more information is needed in order to help address his trouble. The risk of formulating the question as a yes/no question to elicit elaboration is that it may be treated as a simple yes/no question therefore fails to elicit further information that it is designed to do.

Immediately follows qwer’s post is 137’s action on some object on the whiteboard as indicated by the awareness message. The awareness information in the system shows that 137 starts typing and stops (by erasing what’s been typed in his message box). Jason starts typing, which appears to overlap with 137’s attempt of composing message again,

then stops. The next post appears as 137's reply to qwer's post with an explicit reference, a simplified yes, in a rather casual connotation: "Ya." The typing and erasing activities by 137 seem to suggest his hesitance in producing a response to qwer's question. At the same time, Jason's typing and erasing may suggest that he is paying attention to and following along what's going on. One characteristic of a chat system is that the turn-taking mechanism works very differently from face-to-face conversation in that the production of messages can be overlapped even though the appearance of the posts will not be overlapped. One could also observe the production of message by others by reading the awareness information on typing activities. One consequence of this is that a participant could make the decision on whether or when to post based on his observation of whether his interactants are composing a message. From the overlapped typing and erasing activities indicated by the awareness information, we could infer that Jason possibly sees that 137 is composing, presumably a response to qwer's question, so he decides to read that response-to-come first before he posts what he is composing. This hypothesis will need more evidence from the subsequent interactions to reinforce.

Providing a simple confirmation to qwer's candidate answer for the question instead of elaboration on the proposal or the term "hexagonal array" seems to suggest that 137 treats his proposal as unproblematic, implying that he assumes the competence of his group members to understand the problem he proposes for the group to work on, unless it is proved otherwise. 137 then directs his attention to the whiteboard, creating a line on the grid which almost overlaps with an existing line. This action displays certain ambiguities in how it can be taken by the interactants. On one hand, by diverting his orientation away from the chat to the whiteboard, 137 may be seen as concluding the question-response interaction as complete and moving on to a next step of working with the diagram. On the other hand, his action could be seen as starting to illustrate on the diagram, possibly as elaboration of his proposal, as a result of seeing qwer's question as revealing troubles of understanding and taking it up as an elicitation for elaboration or clarification. We see that in the upcoming sequence, 137's action is treated by the third participant Jason as the prior. At the same time, 137's simple affirmative answer and the possible closure of this thread of discussion on "hexagonal array" displayed by his action are not made problematic by the questioner qwer, who makes acknowledgement of 137's answer in the post "ok..." that appears 13 seconds later. There are various methods that a participant could exhibit his achieved understanding on a matter following an explanation provided in response to a question. The ways such understanding is displayed can often demonstrate different levels of understanding. For instance, a change of state display token (Heritage, 1984; 1988) such as "oh, I see" can inform other participants the change of one's cognitive state relevant to the ongoing interaction. One can make next reasonable move in the interaction to show his understanding of prior actions, or one can demonstrate achieved understanding by performing some task and making the action available for assessment (Zemel et al, 2009). Actions performed as demonstration of understanding are stronger indicators for achieved understanding than simple claims. In our case, qwer's delayed acknowledgement "ok" accompanied by three dots "..." indicates certain hesitance of qwer to make an assessment of 137's answer that affirms his candidate answer to his question formulated towards the "shape of the array". It is a less positive claim of his understanding. His question that is designed to elicit

information on the problematic matter “hexagonal array” fails at this point because it has been treated as a simple yes/no question. This is further supported by Jason’s *intervention* to elicit more information on helping him to “see what you mean”.

Part II: intervention of the “failed” question and the escalation structure

As 137 continues with his actions on the whiteboard, Jason starts composing his post shortly after qwer’s acknowledgement. The post appears as rather extended, consisting of two full sentences, as compared to short or abbreviated sentence or fragment of a sentence in a post that is commonly seen in a chat.

Jason: wait—can someone highlight the hexagonal array on the diagram? i don’t really see what you mean...

Jason’s post starts with “wait –”, a “show stopper” (Stivers and Robinson, 2006) that serves to halt the current ongoing interactions and direct the group’s attention to what is to come next. What comes next is a request addressed to the group (including both 137 and qwer) as suggested by the use of “someone” (as in the group). It is supplemented with a second part that appears to be a self-report of his trouble of understanding, which seems to serve as explicating that the purpose for the action being requested is to help the request maker “see what you mean”. By doing this, Jason brings up his trouble of understanding “hexagonal array” from the proposal and makes it relevant to the ongoing interaction in the group, while at the same time provides instructions to the recipients on how the trouble might be addressed. The instructions supply a specific method – “*highlight the hexagonal array on the diagram*” – similar to the method that the group is probably familiar with, which was originally used by 137 in their previous session, highlighting a sequence of squares as a way of illustrating his idea of “side length”. There are a number of assumptions that Jason’s post is making: a) the hexagonal array (presumably the one 137 refers to in his proposal and what qwer is trying to elicit information about) and the diagram of “a bunch of triangles” produced are related: the hexagonal array *is* on the diagram and it *can* be highlighted; and b) once it is highlighted, he will be able to “see” the “hexagonal array” (and understand). By making such a request for demonstration, Jason constitutes the trouble as caused by the lack of reference, which is previously treated by qwer as caused by epistemic differences as we have seen in the analysis. By using “really”, Jason also seems to emphasize that he has made considerable effort in trying to “*see*”, or in other words, understand “what you mean” but has not been successful. The way this post is designed and delivered shows Jason’s great effort on making sure his request is taken up seriously and his trouble gets addressed.

As our analysis before has shown, Jason has had the opportunity to ask a question earlier regarding his trouble of understanding “hexagonal array” presented in 137’s proposal. However he did not choose to do so. Asking a question that displays one’s trouble understanding something can be a delicate matter for participants in a peer group like VMT group (Zhou, 2009), especially when such trouble is considered as caused by one’s lower epistemic stance in comparison to other members, with the concerns of being a competent member, saving face (Goffman, 1967; Lerner, 1996), and so on. Under such concerns, a participant may choose not to ask a question which would risk the chance of losing face. Instead, one may try to use various ways to achieve understanding on one’s

own first. Only when this does not work, one turns to posing a question. In this case, Jason did not choose to ask a question for reason that may not be apparent to us as analysts, which we could speculate as concerns of face issues. The third participant qwer asked a question in a way that does not necessarily position himself in a lower epistemic stance since the question is presented with a candidate answer in contrast to alternatively a direct question such as “what do you mean by hexagonal array?” or a self-report such as “I don’t understand what you mean by hexagonal array”. We have observed that Jason has tried to compose message after that but the message being composed gets erased while 137 starts typing. It may be reasonable for us to infer that Jason has waited to see how that question designed to elicit information is addressed by 137, in the hope that the answer could address his problem as well. He makes his long, complete post only after seeing that qwer’s question has been treated as a simple yes/no question and no further information is provided to help him address his trouble with the proposal. It is in this sense that we characterize Jason’s action in 7:16:41 as an *intervention* and a remedy to the “failed” question by qwer. He sees qwer’s trouble and waits until the answer fails to resolve it, then articulates his trouble (which in a sense is similar to what he sees qwer’s trouble is) explicitly and makes a request for the group to address his trouble more directly. Jason’s directness in revealing his trouble understanding could also be attributed to the fact that another member has expressed a similar concern so that it becomes easier for him to articulate since the risk of losing face by being the only ignorant member has been greatly reduced as a result.

The organization of the interaction also shows a particular procedure by which an inquiry is brought up in the group. In the sequence we have just analyzed, when “hexagonal array” is presented to the group referring to something that yet needs to be established, the group has to deal with the trouble caused by the referential problem. One participant (qwer) first uses a question with a candidate answer to elicit information from the presenter. The way the question is designed does not explicitly call for elaboration. It is a yes/no question that has an affirmative answer as preferred answer, which is what the presenter provides. The question fails to achieve what it is designed to do, i.e. elicit information on the proposal. Jason then intervenes by using a “show stopper” and making a direct request for demonstration that at the same time supplies the particular method for the recipient to perform the requested actions. The request is direct and explicit, hard to ignore without causing considerable interactional trouble (Schegloff, 1968; Schegloff & Sacks, 1973). From this example and a few cases we have observed and analyzed, such procedure by which an inquiry is organized seems to repeatedly occur in small group interactions. An inquiry regarding some trouble participants have is made relevant to the group first in a gentle and less explicit way and a different method is employed that is more direct and explicit once the earlier attempt fails. The inquiry could be done by the same participant or often we see by different participants. A second participant steps in to ask a more direct, reformulated question or make a request upon the failure of the first participant’s attempt. We call this “*escalation*” structure of doing an inquiry in small groups⁵. Perhaps a slightly different perspective can also be taken to inspect the organization of actions in this sequence that is related to the design of question and the

⁵ For more detailed analysis of the escalation structure, see Section 4.3 on “pursuing explanation through reports”.

answer it subsequently demands its recipients to produce. Qwer's question, if recognized as an elicitation for elaboration or explanation of the trouble source "hexagonal array", is designed to call for a response the production of which is similar to instructional work. Jason's "question" (that is, it takes an interrogative form), however, does the work of "request" for demonstration, for which particular instructions are given for doing such demonstration. Therefore, designed as a request, Jason's "question" projects a particular response – a demonstration – that is relatively unproblematic to produce.

Part III: demonstration of understanding and reuse of referential resources

In the sequence that follows, 137 performs a series of drawing actions on the grid of triangles that result in six lines which together resemble the shape of a hexagon (see Figure 4.1.5). These actions on the whiteboard are indicated by the blue squares (the color blue is assigned to 137 matching the color of his text post) in the first line of *Excerpt 4.1.9*, which are designed to serve as awareness information for participants to notify them a particular participant is performing whiteboard actions. The brown squares indicate some parallel drawing actions by qwer that seem rather independent of 137's actions, involving some drawing and deleting actions mainly outside of the grid⁶. Jason's next post seems to accept 137's actions as producing an expected response to his request, in which he offers a mitigated affirmative assessment to the response produced: "hmm... okay". The mitigation of the assessment offered is also reinforced by his following question that seems to be designed to check his understanding of "hexagonal array" by offering a statement regarding some feature of the object for assessment (at 7:17:44). This question is prefaced by "so", indicating that what is being presented is derived from previous actions, i.e. the statement that follows is some understanding of the object "hexagonal array" derived from 137's illustrating actions. Formulated in a form of a statement with a question mark at the end, it offers the statement as an assessable matter for its recipients. The displayed understanding is further illustrated by Jason who points to an area on the grid (that appears to be a hexagon shape, but the smallest unit made up by triangles) using referencing tool provided by the environment and at the same time makes a text post that indicates what's being pointed is an instance of his previous statement offered for assessment.

⁶ The details of those actions are revealed to us by re-playing the session in real time using our "replayer" software.

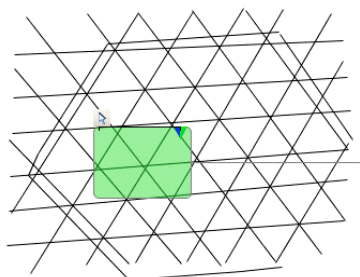


Figure 4.1.5: pointing to smallest hexagonal array

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

Excerpt 4.1.9: Demonstration of

The connection Jason's displayed understanding is making between the smallest unit and the "hexagonal array" as a general concept of an object seems to be oriented to moving the discussion from resolving the trouble with "hexagonal array" to the original proposal of the task of "calculating the number of triangles in a hexagonal array". Jason's question is not explicitly taken up and the immediately following sequence is diverted to a different thread in response to 137's request for help in using drawing tools in the system, at the end of which 137 accomplishes coloring the lines he created to blue and explicitly refers what's been created as "*that hexagon*". Jason subsequently concludes the diverted thread and orients the group to the original proposal by making a new proposal "find a formula" (at 7:20:02, the first line in *Excerpt 4.1.10*) that is clearly connected and built on the original one since finding a formula is supposed for the purpose of calculating the number of triangles (as the original proposal suggests). By orienting to the original proposal from which the source of trouble has arisen, Jason treats the lack of assessment for his displayed understanding as insignificant or at least unproblematic. This shows that the trouble with "hexagonal array" is considered as being addressed and the group is therefore ready to move forward to the next step as proposed by Jason.

In the subsequent sequence, qwer offers a strategy which "sees" the hexagon as 6 smaller

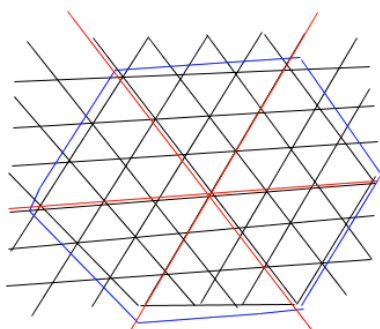


Figure 4.1.6: 6 smaller triangles

Jason 5/16/06 7:20:02 PM EDT: so... should we try to find a formula i guess
 Jason 5/16/06 7:20:22 PM EDT: input: side length; output: # triangles
 qwertyuiop 5/16/06 7:20:39 PM EDT: it might be easier to see it as the 6 smaller triangles.
 137 5/16/06 7:20:48 PM EDT: Like this?
 qwertyuiop 5/16/06 7:21:02 PM EDT: yes
 Jason 5/16/06 7:21:03 PM EDT: yup

Excerpt 4.1.10: reuse the referential resources of "hexagonal array"

triangles in response to Jason's proposal that orients the group to "try to find a formula". This idea is illustrated on the grid (with the "hexagon") by 137 as a way to elicit assessment for his candidate understanding of the strategy. Drawing three red lines intersecting at the center of the hexagon which divide the hexagon into 6 equivalent areas,

the illustration makes use of the hexagon created as a result of the earlier sequence where the trouble with the “hexagonal array” is introduced and dealt with. What qwer offers as a strategy of “finding a formula” (for counting the number of triangles within the “hexagonal array”) also bears resemblance with an earlier observation Jason has made that is offered to check his achieved understanding of “hexagonal array” after it is illustrated by 137 in response to Jason’s explicit request. From our analysis of the process where the group deals with some trouble brought up and moves forward in their problem solving trajectory, we have come to see how the group engage in constructing referential resources as a result of resolving the referential problem. Those referential resources then subsequently become shared artifacts (i.e. the “hexagonal array” on the grid and the small triangles that make up it) that are pointed to and made use of when the group moves on to the next task of counting the number of triangles within the “hexagon”.

Case study 3: Co-construction of an inquiry

bwang8 5/10/06 7:28:28 PM EDT: so we will just have to figure out how many sticks make up 3 by 3 blocks
 ■■■■■■
Aznx 5/10/06 7:29:06 PM EDT: Yes.
 ■
Aznx 5/10/06 7:29:16 PM EDT: After that, we go up to Nth step.
Quicksilver 5/10/06 7:29:20 PM EDT: Yes
 ■■■■■■■■■■
bwang8 5/10/06 7:30:07 PM EDT: ok, how do we figure this out
 ■
bwang8 5/10/06 7:30:17 PM EDT: 3*3 blocks
 ■
Quicksilver 5/10/06 7:30:26 PM EDT: Break it down
Aznx 5/10/06 7:30:27 PM EDT: I'd say look for a pattern.
 ■
Aznx 5/10/06 7:30:33 PM EDT: and yes, break it down.
 ■
Aznx 5/10/06 7:30:40 PM EDT: What other possible ways are there?
Aznx 5/10/06 7:30:44 PM EDT: That we know of?
bwang8 5/10/06 7:30:52 PM EDT: top, middle and bottom
 ■■■■■■
bwang8 5/10/06 7:31:29 PM EDT: top and bottom are 3 by squares

Excerpt 4.1.11: present an approach

down”, bwang offers a more particular strategy: “top, middle and bottom”, followed by an elaboration “top and bottom are 3 by 3 squares”, which seems to align with the “break it down” strategy but more particular on “how” to break it down. Although one may assume that the “top, middle and bottom” refer to those of the 3 by 3 blocks which the group has been oriented to, the way the proposal is designed leaves such reference implicit and up to the recipients to figure out. Quicksilver nevertheless displays he understands by providing an agreement “but yes” (at 7:31:36, not shown in the excerpt), although he has engaged in producing a drawing on the whiteboard during the whole time of this sequence of interaction that appears to be a representation of the pyramid. In later of the interaction after the next sequence we are going to look at, we will see how the

Prior to the sequence under analysis here, the group has come up with their own problem which is to figure out the pattern of growth for a 3-D “pyramid”. They have engaged in defining the problem by making various representation of the pyramid and talking about them. They have come to the agreement that the “bottom level” of the pyramid (for the stage $n=3$) has “3 by 3 blocks” with the total of 9 blocks. Bwang makes a proposal of the next task for the group as figuring out “how many sticks make up 3 by 3 blocks”, which gets explicit endorsement from Aznx. Aznx also displays his competency of understanding the proposal by proposing the next step for the group after what’s been proposed as “go up to Nth step”. The agreement from the other participant Quicksilver seems to endorse both proposals presented. Bwang then goes ahead and poses a question to the group eliciting strategies on how to carry out the proposed task. After both of the participants offer to “break it

reference “it” for the referent that the equation is for. It is not explicit what “it” may possibly be referring to. Using adjacency rule, one could make assumption that “it” probably refers to the *3 by 3 square* since the equation presumably is about number of sticks and the approach presented by bwang is to decompose the 3 by 3 square into the sticks as shown in the drawing. However the use of N in the equation suggests that it is a general formula for any stage of N. Bwang seems to use the example of a 3 by 3 square as a tool to illustrate the approach and help to see the pattern for the number of sticks that is generalized to any N. The equation as a final result of the pattern is presented, derived from the approach that is presented and seemingly understood by one participant, and calls for the recipients to act upon, for example, offer an assessment for it. Bwang makes such call more explicit by supplementing with yes/no question “right?” in a separate post few seconds later. The question explicitly elicits an assessment with a structural preference for an affirmative answer “yes” that conveys a positive assessment.

Receiving no response to his call, bwang makes a post: “N is the level”, which offers additional information by providing an annotation to the equation presented. This action shows that bwang treats the lack of response from the recipients as problematic. It indicates that bwang may be attributing the source of trouble for the problematic situation to the use of N in the equation. Almost at the same time as bwang’s post appears, Quicksilver makes a self report in response to bwang’s question that suggests he is not in the position to offer such an assessment which is called for because of some trouble of understanding he has: “I don’t know.”. Aznx on the other hand makes a direct request to bwang for some action to be done: “Prove it.”. Immediately following this, Quicksilver continues to further make more explicit his trouble with the equation presented by bwang by posing a question directed to bwang. The question “*Where did you get it?*” suggests Quicksilver is having trouble connecting the equation to what’s been presented as an approach to carrying out the task of counting the sticks. It also implies the assumption that the equation is derived from what has been made available using certain reasoning. Therefore the question is designed to elicit some account on how the equation is derived in order to bridge that gap, which is by nature instructional work. In the sequence that follows, the recipient does not perform instructional work but rather allocates the source of trouble somewhere else as some referential problem. The third participant Aznx intervenes by posing a question for which the answer is relatively unproblematic to produce.

The trouble as made relevant by Quicksilver and Aznx regarding the presented equation is taken up by bwang, who neither provides proof as requested by Aznx nor produces an account in response to Quicksilver’s question. Instead, he offers a clarification statement which is designed to address some referential problem as a source of trouble that he is attributing to (*at 7:35:27*). If we look back at how bwang comes to present the equation, we can see there have been a few steps through which bwang defines the task, offers the strategy “break it down”, produces the drawing to show how it is done, then derives the final equation. The process resembles a mathematical proof for the equation, which is what Aznx is asking for. It at the same time would have addressed Quicksilver’s question regarding “where” bwang got the equation. Since such process has already been made available to the group, a response to the request or the question would not appear to what

is needed, therefore another source of trouble has been introduced – a possible referential problem – which a clarification of the reference would adequately address.

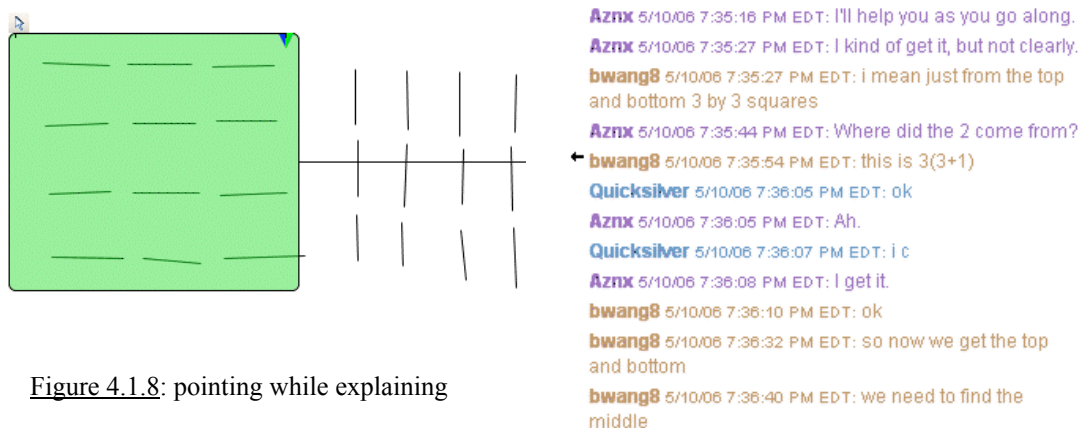


Figure 4.1.8: pointing while explaining

Excerpt 4.1.13: intervention of the question and production of response

A short period of eight seconds passes after *bwang*'s clarification post with no observable activity happening. *Bwang*, who was in the position of providing a response, seems to treat the clarification as sufficient and complete, which apparently is not considered as such by at least one recipient *Aznx*, who poses the following question "*Where did the 2 come from?*". When a question does not get answer that is considered sufficient by the questioner while the answerer considers as concluded, interactional trouble arises that calls for repair from the questioner/requester or self-repair from *bwang*. In this case, *Aznx* offers a repair to the original inquiry that seems to be jointly concerned by both him and *Quicksilver* by posing a reformulated question that is designed to elicit information on a particular part of the equation. By posing the question, *Aznx* treats the source of trouble introduced by *bwang* as not adequate and shows that the clarified reference still does not help address the trouble. *Aznx*'s move also seems to align with the mitigated epistemic stance he takes earlier by offering to help *bwang* with the proof and indicating that he "kind of get it, but not clearly". His question is more particular and shows certain competency he has for being able to ask such a question, compared with *Quicksilver*'s question "Where did you get it?". The question also implies that he is missing that particular part, i.e. "2" in the equation, for understanding the equation, which once is put together, he will be able to "get it" "clearly". Posing such a question is an intervention to the situation where *Quicksilver*'s initial question is not addressed. He acts as someone who probably knows more about this matter than *Quicksilver* who claims "I don't know" and subsequently asks a question that seems to suggest that he has got no clue.

Pointing to the area that covers the left set of sticks (the horizontal ones) using the referencing tool, *bwang*'s makes a statement that "this" – presumably the number of the sticks in the area by pointed to – "is $3(3+1)$ ". It answers the question that where the 2 comes from by dividing the sticks into 2 parts, each with equal amount of them, and supplying a formula that shows how the counting is conducted – three columns of $(3+1)$

sticks results in multiplying 3 by $(3+1)$. Using the number 3 that actually appears on the diagram of stage 3 instead of N , a generalized version for any stage, this response also manages to bridge the disconnection between a math expression for this particular example and a general formula for any stage, which the original “equation” appears to be. This response is treated by both participants as a sufficient answer to the question raised. Both participants indicate their change of understanding status in a rather explicit manner, i.e. “i c” and “I get it.” The trouble is treated as resolved and bwang moves to the next topic by summing up what the group has got now (“the top and bottom”) and orients the collectivity to the next task as “find the middle”.

4.1.3. Question with candidate understanding

In this section, we present our analysis to show the basic sequence structure when a candidate understanding is used to initiate trouble and its variations. When facing troubles of understanding something introduced by one member in the group, one commonly observed method participants use to present their troubles is to ask a question regarding the matter. In a peer group like VMT, there are certain rights and obligations allocated for being a member, under which asking a question can be a delicate matter for that the epistemic stances it allocates could pose potential threat to the peer relationship. One way that participants use to introduce the trouble while at the same time maintaining the peer relationship is to *demonstrate competency* as a peer, which could be math ability or competency of participating. There are various methods participants employ to demonstrate their competency thus position themselves as peers, among which offering a candidate understanding is observed as commonly being used and having significant interactional consequences on the unfolding of “understanding work” group members engaged in doing. Here we present our analysis of a few episodes to show how *offering a candidate understanding* while asking a question is done and what the sequence of understanding work is like when such method is used.

When a candidate understanding of the matter being concerned is offered in a question, it explicitly invites assessment from its recipients, usually, the presenter in particular who introduces the matter, who is treated as the local expert. The presenter then is in the position to offer an assessment, which makes relevant a particular course of actions, such as the production of an account or an alternative when the assessment is negative. Provided such an account or alternative as explanation for the problematic matter, the questioner offers an assessment, which sometimes is followed by demonstration of his achieved understanding in certain ways. Upon the achieved understanding of the matter being inquired, the sequence goes back to order, meaning uptaking the original statement from which the source of trouble arises becomes the relevant move to make, such as assessing the idea presented or performing the task put forward in the proposal. This next move sometimes can be a problematizing move that problematizes the original statement, based on the understanding constructed in the prior sequence of inquiry. The procedure of such sequence is shown as follows (the letter at the end indicates the interactant of the action):

- 1) *statement (such as proposal, idea, etc which contains the source of trouble) (A)*
- 2) *candidate understanding for assessment (B)*

- 3) *assessment (A)*
 - a. *if positive, uptake the proposal/idea (B) END*
 - b. *if negative, alternative understanding is produced (A)*
- 4) *assessment for the alternative/explanation (B)*
- 5) *demonstration of understanding (B) OR*
- 6) *problematizing move (B) goes to 3)*

In the following sections, we present our analysis of several episodes of interaction to show such structure in actions organized around a candidate understanding offered in an inquisitive form, each with certain variations.

Episode 1:

In the following sequence of interaction, a term “triangular numbers”, which is recognizable for mathematically competent people as a math concept, is introduced by a member with handle name “137” in a proposal in which he offers his observation on the pattern of a sequence of numbers. The term “triangular numbers” turns out to be the source of trouble, which both of the two recipients subsequently are engaged in initiating. One participant Jason poses a question that is designed to introduce his trouble of understanding. It offers his candidate understanding of “triangular numbers” for assessment, which at the same time provides particular instruction to its recipient on how an expected response should be constructed. An explanation of “triangular numbers” is produced by the proposal maker – the local expert – as a result of the negative assessment of the candidate understanding. The procedure on how actions are organized in this sequence has variation to the general procedure we present earlier. The variation in this case is particularly a result of the fact that more than two interactants (in this case three) are involved, which is common for a small group:

- 1) *Idea (proposed for assessment) (137)*
 - 1.5) *Question initiating trouble (qwer)*
- 2) *Candidate understanding (Jason)*
- 3) *3b) Alternative understanding/explanation (137) – assessment is implicit*
- 4) *Elaboration (137)*
 - 4.5) *assessment of 2) (qwer) – challenging through offering contradictory observation*
- 5) *Assessment (qwer) – in group setting, assessment can be made from a third participant other than the one who offers candidate understanding*

Analysis:

At the first line of the excerpt (4.1.14), 137 makes a proposal that describes the pattern of the numbers as “triangular numbers”. This line is referencing to qwer’s post that makes explicit reference to a prior post in which an observation on numbers for different stage (defined by “side length”) is reported. What follows the post is some drawing actions by 137 on the whiteboard (which end up producing a hexagon sitting on the bottom orange line) that seems to be relevant to a separate thread of discussion regarding 137’s earlier assertion that one side is missing when counting the number of sticks. The observed diversion of the proposal maker’s attention marks that the proposal is treated as complete and no further elaboration is expected to be offered in the proximity. A proposal of idea like such calls for assessment to be made as the next relevant move. It is for the recipients

to judge the relevancy of the proposal and perform the next action, who when facing troubles of understanding, produce troubles as such for the group to deal with. In this episode we see two distinctive methods are used by two participants, namely qwer and Jason, respectively to initiate their trouble with “triangular numbers”. The next post comes from qwer which consists of a reference to “triangular numbers” in the proposal with the use of quotation marks that emphasizes the direct quote. An explicit reference is also made pointing back to the post of proposal using the referencing tool. A question mark at the end indicates that the object being referenced is problematic. The analysis of Qwer’s post shows that it is designed to point to “triangular numbers” in the previous posting as source of trouble for understanding the proposal and calls for explanation of or elaboration on “triangular numbers” to address the trouble.

- † 137 5/16/06 7:34:52 PM EDT: And I think they're all triangular numbers.
 ■■■■
- † qwertyuiop 5/16/06 7:35:17 PM EDT: "triangular numbers"?
 ■■■■■■
- Jason 5/16/06 7:35:37 PM EDT: you mean like 1, 3, 7, ...
- Jason 5/16/06 7:35:39 PM EDT: ?
- † 137 5/16/06 7:35:59 PM EDT: Like 1,3,6,10,15,21,28.
- † qwertyuiop 5/16/06 7:36:02 PM EDT: the sequence is 1, 3, 6...
- 137 5/16/06 7:36:30 PM EDT: Numbers that can be expressed as $n(n+1)/2$, where n is an integer.
- qwertyuiop 5/16/06 7:36:45 PM EDT: ah

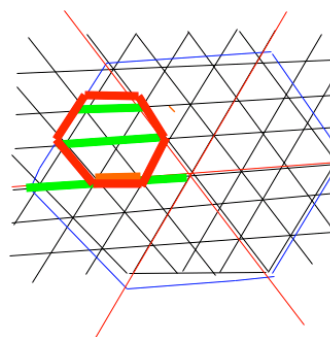


Figure 4.1.9: 137 draws a hexagon shape

Excerpt 4.1.14: trouble with “triangular numbers”

20 seconds has elapsed after qwer’s question, during which 137 continues his drawing actions of producing the hexagon on the grid (see Figure 4.1.9), before Jason posts the following: “you mean like 1, 3, 7, ...”, following which a question mark is added in the subsequent post, turning it into an inquisitive form. This post is clearly addressed to the proposal maker 137, as indicated by the use of “you”. The use of “like” makes connection between what is to come and what “you mean”, an interpretation of the matter being referred to, which presumably comes from what’s been proposed using the principle of proximity for understanding chat interactions. Jason’s question therefore is designed to offer a candidate understanding of the matter “triangular numbers” as an assessable matter. The candidate understanding consists of a sequence of numbers followed by ellipses, which can be seen as a demonstration of how “triangular numbers” looks like. The question makes the next relevant action an assessment from 137, the proposal maker, who is positioned as the local expert on the relevant matter (i.e. “triangular numbers”) with preference for an affirmative answer, i.e. a positive assessment.

When such candidate of understanding is assessed as being incorrect, an account or alternative understanding needs to be produced subsequently as the next relevant action. In this sequence of interaction, the assessment is made rather implicitly by the direct offering of a correction to the candidate understanding (at 7:35:59). By recognizing his turn to “speak” and actually taking it up to do so as to produce a sequence of numbers following the structure provided by the candidate understanding, 137 positions himself as

the local expert here. What he produces is recognized as a correction which expands the sequence from 3 to 7 numbers and offers a different third number to the original sequence Jason's candidate understanding of the "triangular numbers" is also taken up by qwer in the subsequent post that appears shortly after 137's, where he presents the structure of "the sequence" – referring to the sequence they are observing and dealing with here – which appears to be "1, 3, 6...". By using the explicit referencing to point back to Jason's post where a sequence is given as "1, 3, 7, ..." in an attempt to describe "triangular numbers", qwer's post makes contrast of the two therefore serves to problematize the discrepancy being observed. In the subsequent post, 137 produces a characterization for a sequence of numbers that reads like a mathematical definition. The characterization itself may serve as a definition of "triangular numbers" alone since it provides a generalized description of the feature of such sequence. When offered here after listing the beginning numbers in such a sequence, it complements the effort of defining "triangular numbers" that first takes the form offered by the inquirer. 137's explanation on "triangular numbers" is acknowledged by qwer in his post 15 seconds later where an assessment is made by a marker of achieved understanding "ah". Although qwer's problematizing move is not explicitly taken up, the assessment qwer makes suggests that the issue raised has been resolved. 137's sequence of numbers offered as correction to Jason's serves to resolve the discrepancy since its first 3 numbers are consistent with what qwer presents.

30 more seconds after qwer's assessment, 137 concludes this line of discussion by a "So"-prefaced question that is designed to end the current topic and switch to another: "*So are we ignoring the bottom orange line for now?*" with explicit referencing to an earlier post where the subject was brought up. The fact no further post is made by qwer and no assessment is made by Jason also serves to indicate that the sequence on the trouble of "triangular numbers" is treated as complete.

Episode 2:

In this case, a term "colinear sides" is introduced by a member with handle name "qwer" who proposes "an idea" – an approach to solving the problem for the group to consider. The referent of "colinear sides" however is yet to be figured out therefore turns out to be the source of trouble. Participant 137 offers a candidate understanding of "colinear sides" that consists of drawing actions and a text post. It receives a negative assessment from the idea presenter, who subsequently offers an alternative using the method provided in 137's candidate understanding. Qwer's explanation turns out not adequate to address the raised trouble and a revised candidate understanding is offered. The sequence repeats the general procedure of actions. In summary, the procedure can be outlined as:

- 1) *proposal (an idea offered) (qwer)*
- 2) *candidate understanding (137)*
- 3) *assessment (qwer)*
- 4) *alternative (qwer)*

The subsequent sequence repeats the procedure:

- 5) *statement (reiteration of the proposal) (qwer)*
- 6) *candidate understanding (137)*
- 7) *alternative/elaborated explanation (qwer)*

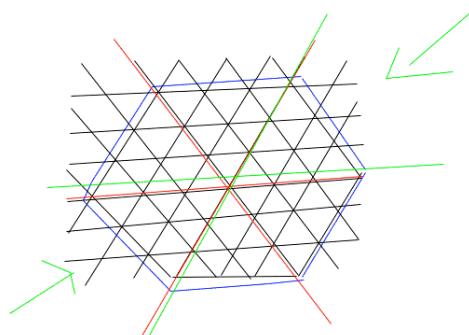
- 8) *assessment (137)*
- 9) *problematizing move (137)*

Analysis:

In the following example, “an idea” is proposed by qwer to the group to consider at 7:25:48:

qwer: *an idea: Find the number of a certain set of colinear sides (there are 3 sets) and multiply the result by 3*

It is the first time that the term “colinear sides” is being introduced to the group, upon which no further elaboration is made. It does not appear to be recognizable by the participants or the analysts as a predefined mathematical concept or an existing term in math therefore likely to cause trouble of understanding for its recipients. Once the idea is put forward, it calls for assessment from the group members. However, assessment is not provided in the next few turns where some other issue raised by the moderator immediately preceding qwer’s proposal is being attended instead. More than half a minute after qwer’s post, 137 starts a series of drawing actions as indicated by the little squares in the chat area (the first line of the excerpt) by which he creates a pair of green lines intersecting at the middle of the highlighted “hexagonal array” on the whiteboard and a pair of arrows pointing to the two opposite angles formed by the intersected lines (as shown in *Figure 4.1.10*).



```

#####
t 137 5/16/06 7:26:36 PM EDT: As in those?
t qwertyuiop 5/16/06 7:27:05 PM EDT: no-in one triangle. I'll draw it..
#####
qwertyuiop 5/16/06 7:28:10 PM EDT: those
#####
qwertyuiop 5/16/06 7:28:28 PM EDT: find those, and then multiply by 3
137 5/16/06 7:28:50 PM EDT: The rows?
qwertyuiop 5/16/06 7:30:01 PM EDT: The green lines are all colinear.
There are 3 identical sets of colinear lines in that triangle. Find the
number of sides in one set, then multiply by 3 for all the other sets.
137 5/16/06 7:30:23 PM EDT: Ah. I see.
#####
137 5/16/06 7:31:07 PM EDT: Wait. Wouldn't that not work for that one?

```

didate understanding

Excerpt 4.1.15: trouble with “colinear sides”

What immediately follows is 137’s text post that appears in interrogative form, with explicit reference to qwer’s original post: “*As in those?*” (Excerpt 4.1.15). The use of “As” makes connection between “those”, possibly what has been produced in the immediately preceding actions by 137 and the source of trouble that seems to arise from qwer’s post that is being pointed to. In particular, “As” being a relationship term suggests that the two things of which the relationship is being referred to are representations of the same matter. If we look more carefully at what’s been produced on the whiteboard by 137, we can see that the two green lines overlap with two of the three red lines created earlier (which intersect at the center), which seems to illustrate how the “hexagonal array” can be divided into six smaller triangles. The pair of arrows seems to be used as a pointing tool to direct recipients’ attention to the two opposite angles made by the green lines. By posing the question designed with a preference for an affirmative answer, 137

presents his interpretation of “colinear sides” as an assessable matter to the group. Offering such a candidate interpretation for assessment is done through creating shared artifacts on the whiteboard, using graphical reference, questioning in text that makes use of explicit reference. The recipient, in this case the idea presenter qwer, is put in the position as a local expert on the matter to provide evaluation on whether the candidate interpretation is correct. The candidate interpretation initiates the talk on potential trouble of understanding what is being proposed in the idea, which yet to be produced and worked out by the participants. If affirmative assessment were provided, the interaction may proceed with taking up qwer’s idea and moving on to the next step. However in the case when a negative assessment is made, the trouble will subsequently be produced therefore needs to be attended to. It would call for the production of an account, in this case, an alternative interpretation of the source of trouble, i.e. colinear sides, would need to be provided.

From our analysis presented, we have come to see how 137’s candidate interpretation of “colinear sides”, consisting of the production of artifacts on the whiteboard and the text posting of a question, does the work of presenting a possible trouble for the group to check. When a negative judgment is made, the trouble is then subsequently produced and needs to be dealt with by the group. This at the same time is a way of organizing participation so that troubles can be co-constructed. Alternative ways of presenting a trouble like this to the group could be asking a question such as “what does the colinear sides mean?”, or making a report regarding one’s knowledge stance such as “I don’t understand what you mean”. They do different work in term of how they *organize the participation* in the group. When questions or reports are used to produce the trouble, they position the questioner or the reporter as less knowledgeable or less competent in regards to the matter at hand compared with its recipient that the question or report is directed to. *Producing a candidate interpretation or understanding*, on the other hand, demonstrates participant’s competency as being a member of the peer group, and positions one as not necessarily less knowledgeable or less competent than the recipients. The trouble is not presented as something pre-existing but being tested and only gets co-constructed when the candidate understanding is assessed as incorrect or inadequate.

In the sequence that follows, candidate understanding from 137 is rejected as being incorrect and an alternative is subsequently presented and illustrated by qwer. A text post by qwer offers the negative judgment with correction “in one triangle” in contrast to the two opposite angles pointed to by 137. At this point, the trouble regarding “colinear sides” has been co-constructed by 137 and qwer and becomes a matter for the group to attend to. In the same post, qwer makes an announcement of his actions to come: “I’ll draw it ...”. The use of future tense “I’ll” and the ellipses at the end indicate that it is projecting activities “draw it” to come, “it” referring to the matter that 137’s interpretation is for, i.e. the “colinear sides”. This characterizes what is to come as activities of producing an alternative to 137’s candidate interpretation that has been rejected. Qwer subsequently engages in a sequence of actions on the whiteboard. He starts with moving the horizontal line produced by 137 further down to align more with the red line that crosses the center of the hexagon shape, then moving the other line away from the grid to the right. 137 then removes the arrow at the upper corner. Qwer

continues to move the line off the grid back to the center while 137 moves away from the grid the first line that qwer has made adjustment on. His actions seem to suggest that 137 is trying to help out by moving his own drawings out of the way, which demonstrates his understanding for qwer's actions and projections for actions to come. Qwer moves the two lines back to align with two parallel lines within the upper left triangle and adjusts their length to fit within the triangle. He adds the third green line that sits at the top of two parallel lines, which also fits within the triangle (see figure 4.1.11). 137 then thickens the lines one by one as qwer makes the text post: "those" (see figure 4.1.12). This can be seen as highlighting the thin green lines created by qwer, which previously appear to be not so easy to see when overlapped with the existing black lines on the grid.

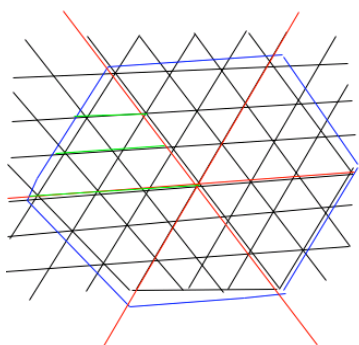


Figure 4.1.11: qwer's illustration

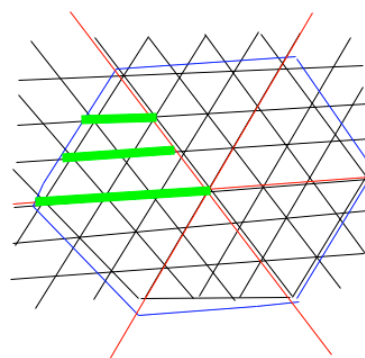


Figure 4.1.12: qwer's illustration highlighted by 137

"those" presumably refers to what has been produced, the three green lines, or possibly some other objects that are made visible as a result of these lines on the existing diagram of "a bunch of triangles". Taking qwer's characterization of the actions into account, "those" are constructed as an alternative and correction to 137's interpretation of "colinear sides". Qwer continues in the following post to provide what looks like instructions on how "those" can be used. The post appears to be a close reiteration of his proposal of idea except that "those" is used as a replacement for "the number of a certain set of colinear sides (there are 3 sets)".

However, the trouble does not seem to have been resolved until this point for that 137, after 20 seconds or so, only poses another candidate understanding of what qwer has presented as an explanation to "colinear sides": "The rows?", that calls for assessment from qwer. A similar method is being used here for presenting a possible trouble regarding understanding of "those" by offering a candidate understanding. What "the rows" may be referring to may appear puzzling for analysts at the first glance, but it does not appear to be problematic for the participants, for no observable action is done to make it as a source of trouble. The next post produced by qwer seems to demonstrate that he understands that the "rows" are not referring to the same matter as "colinear sides" in his proposal. It is worth mentioning that prior to qwer's proposal of the idea which introduces the source of trouble – the "colinear sides", the two participants, namely Jason and 137, are oriented to discussion about finding the number of small triangles within one of the six bigger triangles that make up the highlighted hexagon. During the discussion, 137 makes an observation of the number of triangles as "each one has 1+3+5 triangles", which is subsequently supplemented with a generalized math expression presented in a

questioning form “It equals $1+3+\dots+(n+n-1)$ because of the ‘rows’?”. The term “rows” appears there as surrogates for the rows of triangles, which happen to be what are being underlined by the three green lines created by qwer. The reuse of “rows” by 137 here therefore possibly is referring to the rows of triangles as his revised understanding of the “colinear sides” . Such understanding may also have to do with the fact that qwer’s proposal does not explicitly state whether the idea is for finding the number of triangles or sides (i.e. sticks).

When the candidate understanding is assessed as incorrect, production of a correction, an alternative or an account for the negative assessment is being called as the next relevant action, as we have seen in the preceding sequence of interaction. In the next post, an elaborated explanation is produced by qwer as a response to 137’s question. Although an explicit assessment is not made regarding the candidate understanding “the rows”, the elaborated explanation shows that it is being treated as incorrect. This post consists of three full sentences, which is unusual for a chat environment where fragments of sentences and abbreviated expressions are observed as being commonly used, often for the purpose of competing for the turn of “speaking”. It clarifies that “the green lines” are what he has produced and illustrated, not “the rows (of triangles)”. The proposal is reformulated for the second time. After about 20 seconds silence, 137 displays his understanding of the explanation provided that starts with “Ah.”, a marker for an achieved state of his cognitive change, followed by a report of his stance in regards to the achieved understanding “I see”.

From the analysis of the interaction sequence above, we see what qwer produces to address the trouble introduced regarding understanding “colinear sides” at the beginning consists of the production of objects on the whiteboard as representation of the matter, followed by two brief text posts. The representation is referred to as “those”, the ambiguity of which causes the subsequent trouble to arise. The succinct text explanation seems to assume that what’s being explained has been made clear through the production process on the whiteboard. It also assumes the competency of its recipients to understand what’s been produced as a way of addressing the trouble. Upon failing to receive confirmation of understanding from the recipients, a more elaborated version with more details is produced to repair the previous explanation.

The trouble with “colinear sides” arises from the *lack of referential resources*, that is to say, when “colinear sides” is introduced as a not-yet established matter either in math or in the group’s past experiences, it refers to something that yet to be constructed in order for the recipients to be able to “see”. The subsequent interaction can be seen as how participants engage in co-constructing the referential resources. 137 first builds referential resources representing his interpretation of the matter as a candidate and puts it forward for assessment. It therefore serves as pre-initiator of the potential trouble. It elicits the construction of referential resources for an alternative, if the candidate understanding is assessed as incorrect. By building the referential resources for the candidate understanding, it at the same *offers a particular method* for its recipients to construct the response. The recipients are expected to draw on the existing “hexagonal array” and point out “colinear sides” if an alternative is to be offered. This method is

adopted by the recipient qwer, who introduces the problematic term “colinear sides” at the first place. In fact, some of the resources (such as the green lines) created by 137 are reused in the production of referential resources for “colinear sides”. While qwer is trying to build the referential resources, 137 tries to help out by moving objects, possibly based on his judgment of the projected actions of qwer. 137 also builds on qwer’s finished product and highlights the three lines to make them more salient. A further question “The rows?” constitutes the trouble at this point after qwe’s efforts in constructing and pointing out the “colinear sides” as referential problem, which subsequently leads to production of a more detailed explanation in order to clarify the troublesome referent. Analysis of the process reveals that the referential resources for “colinear sides” are co-constructed by the group. Participation in the co-construction is organized along the unfolding of interaction that how the trouble is introduced and dealt with in the group.

Following 137’s display of his understanding that he now “sees” the “colinear sides”, 137 produces the orange object on the grid in resemblance to the shape of a hexagon, for which he poses a question in the immediately following post:

137 7:31:07 PM: *Wait. Wouldn't that not work for that one?*

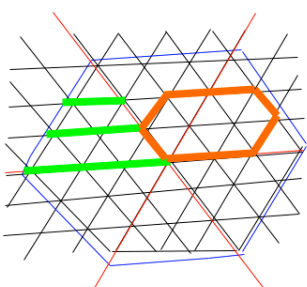


Figure 4.1.13: problematizing move

137’s question is prefaced with “Wait.,” a show stopper that is used to halt the ongoing interaction and draw the group’s attention to what is to come. Formulated as a *reversed polarity question* (RPQ) (Koshik, 2003; 2005) that is really used for eliciting a “reversed” answer, which in this case is affirmative, i.e. “yes, that would”, the “question” is not an information question that elicits unknown information but instead conveying an assertion that “*that would NOT work for that one*”. How is the assertion relevant to the preceding sequence? If we take a look at the sequence that the assertion comes immediately after the discussion regarding the trouble with “colinear sides” (which 137 concludes with a self-report as a positive assessment), we come to see that now it becomes relevant to assess the original proposal made by qwer: “*an idea: Find the number of a certain set of colinear sides (there are 3 sets) and multiply the result by 3*”. Now it seems clear that the assertion serves to offer a rather negative assessment to “that” – the “idea” of using “colinear sides”, which has been co-constructed as a result of the prior sequence. The second deictic term “that one” seems to refer to the object that 137 has just constructed on the grid. 137’s question is treated as assertion by a third participant in the group – Jason – who has remained silent during the process of dealing with the trouble in that he offers an agreement: “yeah”, followed by his reasoning for such an agreement: “because that’s irregular”. It is not only an assessment to the proposed idea but also problematization by asserting that it would not work for certain cases characterized as “irregular” ones as illustrated by the orange “irregular” hexagon. Such problematizing move made by 137 and concurred by a third participant Jason is a result of the prior sequence where a trouble is introduced and resolved and the reasoning process is explicated thus becomes available for examination. The problematizing move is also made by creating an object on the grid, which may have

made use of the referential resources constructed during the prior sequence of dealing with the trouble.

Episode 3:

This episode of interaction is another example that demonstrates the basic procedure of such sequence as we have explicated. In this episode, a candidate understanding is offered as a question regarding a math expression produced on the whiteboard presented as a formula for the group to consider. A negative assessment of the candidate understanding is made by the presenter, followed by an alternative as explanation and further elaboration. The questioner provides assessment to the alternative. The procedure is as follows:

- 1) *proposal (as a math expression produced on the whiteboard) (bwang)*
- 2) *candidate understanding (quicksilver)*
- 3) *assessment + alternative (bwang)*
- 4) *assessment of the alternative/explanation (quicksilver)*
- 5) *elaboration (bwang)*

Quicksilver 5/10/06 7:50:18 PM EDT: It goes up by one every time because n=1 rite?

bwang8 5/10/06 7:50:38 PM EDT: no, n start at 1

Quicksilver 5/10/06 7:50:46 PM EDT: oh yeah!!!

bwang8 5/10/06 7:50:46 PM EDT: this is a recursive function

Quicksilver 5/10/06 7:50:46 PM EDT:

bwang8 5/10/06 7:51:26 PM EDT: when n=1, plug 1 into the right equation\

$$\sum_{n=1}^n = 4n(n+1) + (n+1)^2$$

Excerpt 4.1.16:

Figure 4.1.14: math expression produced on the whiteboard by bwang

Analysis:

In this sequence of interaction, Quicksilver offers a candidate understanding regarding a math expression bwang drew on the shared whiteboard (see *Figure 4.1.14*). It follows up the preceding actions including bwang's drawing actions of creating the object and Quicksilver's prior attempts in introducing his trouble with the math expression, which have not been attended by the local expert bwang. The referent of Quicksilver's candidate understanding – the math expression – is made available to the recipients by its sequential placement following those relevant preceding actions and the use of deictic referential term “it”. The candidate understanding consists of a statement that concerns with how “n=1” should be interpreted and an inquisitive marker at the end “rite?” that makes the statement an assessable matter for its recipients and calls for an assessment rather explicitly. With a preference of affirmative answer to this yes/no question, the design of the question makes the production of an account relevant, which often involves offering an alternative to matter under assessed, if a negative assessment is made.

In response to this call for assessment, bwang offers a negative assessment followed by an alternative – “n start at 1” to Quicksilver's candidate understanding. The alternative receives exclaimed positive assessment from Quicksilver that also marks the change of his status of understanding the relevant matter (Heritage, 1998). Following the alternative understanding regarding the interpretation of “n=1” that is specifically raised in Quicksilver's candidate understanding, bwang continues on providing a characterization

of the math expression of which “ $n=1$ ” is a component using a mathematical concept “a recursive function”. Upon receiving no explicit response, bwang further offers specific instruction on how the “function” is supposed to be manipulated by giving an example of the “ $n=1$ ” case.

From the analysis of this sequence of interaction, we have come to see the basic procedure involved with a candidate understanding: a candidate understanding regarding an object that is the source of the trouble is offered for assessment, a negative assessment is made and an alternative is subsequently produced, and an assessment to the alternative from the participant who had the trouble is provided.

In examination of the interactions immediately preceding the sequence we have analyzed, we also have come to think about how offering a candidate understanding as a method of introducing trouble to the group may be different from other methods such as making a self-report. Prior to Quicksilver’s offering his candidate understanding for assessment, two attempts of making his trouble with the math expression relevant have been made that include making a self-report regarding his math ability relevant to the matter and making a request that someone “reminds” him because he has learned but forgot “how to solve that thing”. Both the self-report and the request serve to elicit explanation of the matter, which by nature resembles *instructional work* that may mean lengthy step-by-step instruction in order to instruct someone of “recursive function”, as characterized later by the local expert bwang who proposes the math expression at the first place. Such instructional work is usually less preferred in a peer group like this for it is not what the peer group is set up for. Instructional work also may imply that potential threats may be posed to the peer relationship among such a group where equal competency is assumed. A candidate understanding of the troublesome matter in this case helps to locate the particular source of trouble (i.e. the interpretation of $n=1$ in the math expression) or serves as a starter to elicit explanation of the matter (i.e. the math expression) as a whole. It transforms instructional work which otherwise would have been called for to assessment, which is relatively easier to make compared to potential lengthy instruction. Making assessment as the next reasonable move is rather compelling and interactionally harder for its recipients to ignore. By offering a candidate understanding for assessment, one positions the recipients as more knowledgeable in relation to oneself but at the same time positions oneself as a competent member of the group.

Episode 4:

In the following example, a candidate understanding regarding a proposed idea – a strategy for finding the number of triangles – is offered as initiator of some potential trouble and receives positive assessment. The construction of it establishes referential resources which are made use of later on by participants in building upon the proposed idea and moving along the problem solving trajectory.

At the first line of the excerpt (excerpt 4.1.17), Jason makes a proposal of the next task for the group, engaging the group as a collectivity, followed by his own action of taking it up by providing some idea of what the formula may consist of. In response to the

proposal, qwer offers an idea that seems relevant to finding the number of the triangles. Such relevance is established by the sequence of the interactions and the reference to number of triangles in qwer's idea. An idea like this put forward is of the recipients' matter to assess, and potentially act upon. A shared understanding of what's been proposed needs to be constructed for such assessment to be made or action taken. A candidate understanding of qwer's idea is offered by 137 that consists of a text posting (at 7:20:48) and drawing actions on the whiteboard that result in three red lines intersecting at the center of the "hexagonal array" illustrated by 137 in the sequence prior to this (see Figure 4.1.15). The text posting "Like this?" projects actions to come and orients recipients' attention to the projected actions. It at the same time displays the relation between what is being projected and qwer's idea that what he is going to construct is a candidate understanding of the idea. The relevancy is also made obvious by the use of explicit reference to the preceding post from qwer. Formulated in an inquisitive form, 137's post makes the candidate understanding become an assessable matter for the group and explicitly elicits assessment.

This episode of interaction shows an alternative procedure when a candidate understanding is being assessed by the presenter as correct therefore the trouble is not initiated. This procedure is straightforward:

- 1) *proposal (Jason)*
 - 2) *idea proposed (in response to proposal) (qwer)*
 - 3) *candidate understanding (137) – consists of text posting and objects from drawing actions*
 - 4) *assessment (qwer) – positive*
 - 5) *assessment (Jason) – positive*
- End of sequence*

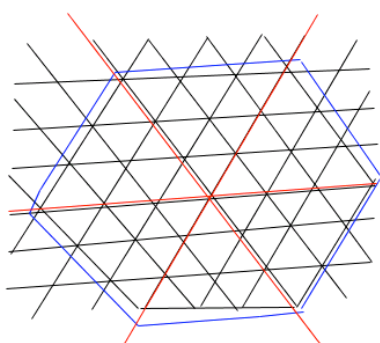


Figure 4.1.15: illustration of candidate understanding

Jason 5/16/06 7:20:02 PM EDT: so... should we try to find a formula i guess

Jason 5/16/06 7:20:22 PM EDT: input: side length; output: # triangles

qwertyuiop 5/16/06 7:20:39 PM EDT: It might be easier to see it as the 6 smaller triangles.

† 137 5/16/06 7:20:48 PM EDT: Like this?
■■■■

qwertyuiop 5/16/06 7:21:02 PM EDT: yes

Jason 5/16/06 7:21:03 PM EDT: yup

Excerpt 4.1.17: a candidate understanding receives positive assessment

Analysis:

The three lines on the diagram as a result of 137's drawing actions or whatever objects they may depict to the participants are received by both participants qwer and Jason as a candidate understanding, who subsequently makes a positive assessment respectively. Three lines intersect at the center of the hexagon, which equally divide the hexagon into six parts, each of which is a triangle. "It" refers to finding a formula for the number of

triangles. If negative assessment is made, similar illustrating actions would be relevant to provide an alternative (i.e. it provides method for constructing the expected response if the potential trouble turns out to be trouble). “6 triangles” was first mentioned by Jason prior to this when they deal with the trouble of “hexagonal array” but not attended. It was illustrated by Jason differently because it refers to the minimal unit of hexagon that is made up by 6 triangles. “*the 6 smaller triangles*” is illustrated by referring to the ones that make up the highlighted big “hexagonal array”.

Qwer offers a strategy of counting the number of triangles (if considered together with the proposal that calls for action: try to find a formula). In the following example, in response to the proposal “try to find a formula”, qwer proposes a strategy of “seeing” the hexagon as 6 smaller triangles without specifying the referent. 137 offers the construction of the referential resources for the “6 smaller triangles”. “Like this?”: “this” projects the actions he is going to perform. By constructing the 6 triangles, 137 *displays his understanding* (reformulates what “see it as the 6 smaller triangles” means) and at the same time puts it forward for assessment by others, particularly, the proposal maker qwer. The later discussion around the strategy for counting the number of triangles makes use of the resources constructed: candidate understanding complements the proposal idea and explicates it. qwer and Jason build upon the idea of 6 smaller triangles illustrated by 137. For example, 137 at 7:22:19 posts “Each one has 1+3+5 triangles”, referring to each one of the six “smaller” triangles and presenting a way of counting the little triangles row by row within the “smaller triangle”. (more on this online environment how it gets done vs. face-to-face: e.g. separation of text and actions and organized in a particular way.) 137 subsequently continues with offering a generalization of the number of triangles built upon what he has just offered (1+3+5) and seeks affirmation that his reason of generalizing is correct. This episode is a good example of collaborating on problem solving among the three members: display steps in reasoning (public for examination) and steps in problem solving are built upon each other’s contribution. Jason’s problematizing move and qwer’s offering of a new approach on “finding the formula” for the number of triangles.

4.2. Making an assertion

Another method we have found participants regularly use to initiate troubles of understanding is to make an assertion. Conveyed in a reversed polarity question (RPQ) (Koshik, 2003; 2005), such assertion is designed to introduce a different or conflicting understanding to what has been presented therefore shows a strong epistemic stance of the actor. Presented in an interrogative form, it demands a yes/no answer that serves as positive/negative assessment. A positive assessment shows an agreement to the assertion whereas a negative one conveys a disagreement, putting the assessment maker in the position to produce an account for the disagreement, such as production of an explanation.

4.2.1. Case Study 1

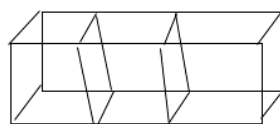
In the sequence that immediately follows, we will see how trouble arises from a *referential problem*, which the participants work together to resolve by building

referential resources needed. We first start with analyzing how Quicksilver makes his trouble relevant to the ongoing interaction in the group by *making an assertion*.

bwang8 5/10/06 7:36:32 PM EDT: so now we get the top and bottom

bwang8 5/10/06 7:36:40 PM EDT: we need to find the middle

Quicksilver 5/10/06 7:37:14 PM EDT: i don't understand something



Excerpt 4.2.1

Figure 4.2.1

The sequence to analyze starts with bwang's two consecutive postings (Excerpt 4.2.1 at 7:36:32 and 7:36:40). In his first posting, bwang concludes a prior sequence that the group has engaged with by summarizing what the group as a collectivity has accomplished – “*we get the top and bottom*”. The summary is indicated by the use of “so” preface and explicit reference to current state “now”. The second posting orients the group to the next task that is described as “*to find the middle*”. This proposal of the next task is aligned with the strategy bwang has offered in response to the other two members' approach of “break it down” in order to count the sticks that make up “3 by 3 blocks” – to “break it down” as “top, middle and bottom”. Such proposal calls for uptake from the recipients such as offering an idea of how to find “the middle”. However, the *progressivity* of interaction is interrupted for that some trouble is introduced and the holding of “floor” (i.e. whose turn is to “speak”) is changed. Bwang's characterization of the prior sequence turns out to be problematic for one of the participants with handle name Quicksilver.

There is about half minute silence before the next post from Quicksilver, which indicates interactional trouble of some sort, in this case, that recipients may have in acting on the task “to find the middle” that they are being oriented to. This opens up the opportunity for the proposal maker to elaborate on what has been proposed or continue with acting on it, as well as for the recipients to make inquiry on the current proposal or some previous matter. The next post from Quicksilver appears to be a self-report (at 7:37:14) on the status of his understanding of “something”. Formulated as referring to something that is yet to be described, the report serves as an *opener* of more specific formulation of the trouble to come. Such generic report of troubles of understanding can also serve as an *invitation* for others to elicit a more specific inquiry or description of the problem from the reporter, especially when the reporter may not be competent enough to produce an adequate inquiry so the inquiry could be co-constructed with the involvement of others (see Section 4.3 analysis of how ssjnish introduces his trouble of understanding to the group). Report like this halts the ongoing sequence of interaction, orients the group's attention to what may come next, and holds the floor of interaction. In this case we analyze, Quicksilver subsequently poses a question prefaced with “um...”, an indicator of some hesitance, possibly with the following question being produced (first line in *Excerpt 4.2.2*). The question is explicitly addressed to the author of the prior posting(s), i.e. bwang, considering the use of deictic term “you”, the rule of proximity in online chat, as well as the direct quote of “the top and bottom” in bwang's posting, therefore puts bwang in the position of being accountable for producing an answer to the question. It points to

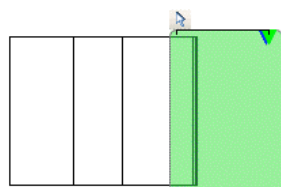
“the top and bottom” in bwang’s prior post as the source of trouble and constitutes it as a problematic matter for the group to attend to, which quickly gets acknowledgement from bwang in the immediately following post.

Quicksilver 5/10/06 7:37:28 PM EDT: um...what do you mean it is the top and bottom
 bwang8 5/10/06 7:37:37 PM EDT: oh
 Quicksilver 5/10/06 7:37:39 PM EDT: it is a pyramid with a flat face right
 bwang8 5/10/06 7:37:47 PM EDT: let me explain
 Quicksilver 5/10/06 7:38:38 PM EDT: This face could go against a wall(this is a top view)

Excerpt 4.2.2

to attribute the trouble to the possible different orientations to how a pyramid is defined – a task they have engaged in doing prior to the task of counting the sticks that make up the pyramid. The post consists of a statement that describes the pyramid as one with a “flat face”, appended by an inquisitive marker “right” at the end, eliciting an affirmative assessment to the statement, i.e., an agreement. Together with the prior post where a question is posed, instead of conveying an information-seeking question from someone who holds a weaker epistemic stance, they serve to *convey an assertion* that use of “the top and bottom” would not make sense for a pyramid defined as such – “a pyramid with a flat face”.

In the sequence follows, the two participants, Quicksilver and bwang, seem to be oriented to two parallel threads of actions and may not necessarily attend to each other’s contributions closely until at a later point. Quicksilver is oriented to producing a representation of the “pyramid with a flat face” that involves a series of drawing actions on the shared whiteboard and text annotations in the chat area with reference to objects constructed on the whiteboard. During the process, he engages the recipients to producing a shared understanding of what he is illustrating by eliciting assessment to his illustration of how the pyramid is defined. At the same time, bwang seems to treat Quicksilver’s question “what do you mean it is the top and bottom” as eliciting an explanation thus is oriented to producing an explanation on “the top and bottom” that involves constructing objects on the whiteboard as referential resources, which later are used to illustrate the top, middle, and bottom.



Quicksilver
 shape of a square

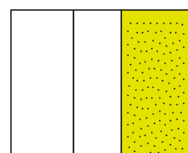
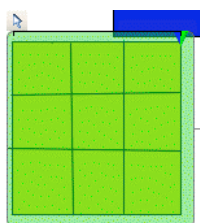


Figure 4.2.3
 starts with drawing a
 three vertical rectangles (see

Figure 4.2.2 which he makes reference to the right most one in his text post: “This face could go against a wall” and supplements with an annotation of the graph using parenthesis – “this is a top view” (at 7:38:38). Quicksilver’s drawing actions and text post that makes reference to part of the object created show that he is trying to illustrate “a

explicit uptake from Quicksilver, who immediately moves on to highlighting the “top level” of his representation of the pyramid and elicits assessment for his assertion, i.e. candidate interpretation of “the top”.



← Quicksilver 5/10/06 7:40:18 PM EDT: So this is against the floor underneath the other two levels
 bwang8 5/10/06 7:40:35 PM EDT: yes
 Quicksilver 5/10/06 7:40:43 PM EDT: ok...continue then

Excerpt 4.2.4

Figure 4.2.5

Following Quicksilver’s question, bwang marks with scribbles the sticks on the top of the block that he has constructed (*Figure 4.2.4*). Bwang’s following post again uses “just” to indicate mitigated disagreement of some sort and “the bottommost level” in contrast to “the top level” in Quicksilver’s assertion. Instead of offering an assessment of Quicksilver’s illustration of this particular part of the “pyramid”, bwang treats how the pyramid is defined as not relevant here but the referential problem, i.e. the approach he offered is for the “bottommost level” of the pyramid rather than the whole pyramid. This clarification of what they are working on gets endorsement from the third participant Aznx. Bwang then offers an alternative to Quicksilver’s candidate interpretation of “the top”, which makes reference to what he has just constructed on the whiteboard – the sticks marked with scribbles (7:40:04). Quicksilver, however, does not seem to have been attending to bwang’s contributions so far and continues to illustrate the bottom level (i.e. “against the floor underneath the other two levels”) of the pyramid he perceives in order to elicit an agreement. This illustration finally gets explicit positive assessment from bwang.

It is at this point that Quicksilver stops pursuing an assessment to his representation of the pyramid and starts to direct his attention to bwang’s actions by offering an acknowledgement to bwang’s assessment and a request for bwang’s continuation of producing the explanation (Excerpt 4.2.4, at 7:40:43). This may be in response to bwang’s positive assessment made regarding the representation of the “pyramid with a flat face” he has produced and illustrated therefore the cause of trouble he tries to attribute is excluded therefore some other cause needs to be introduced. This marks a shared understanding of how the pyramid is defined has been clarified and constructed. Bwang then illustrates “the middle” using referential term “all the vertical lines” and an explicit reference to the block of 3 cubes he has created, which gets acknowledgement from Quicksilver (see Excerpt 4.2.5). He continues to explain “the bottom” and poses a question to elicit assessment from the recipients when such assessment is not offered, which may indicate troubles of understanding. He also offers a self assessment of his explanation as being “pretty bad”. Such downplay projects troubles of understanding with the explanation and treats them as reasonable thus interactionally makes it easier for such troubles to be presented by the recipients if any. Both Quicksilver and Aznx offer their

assessment upon eliciting. This sequence is concluded as complete and they move on to another topic. The completion of the sequence is marked by a period of silence more than one minute and a marker of changing the topic by Aznx's post prefaced with "So", in which he elicits proposals for next topic: "So what should we do next?".

- ← **bwang8** 5/10/06 7:41:02 PM EDT: all the vertical lines are consider the middle
Quicksilver 5/10/06 7:41:21 PM EDT: ok
bwang8 5/10/06 7:41:32 PM EDT: and the rest are the bottom
bwang8 5/10/06 7:41:48 PM EDT: which has the same number of sticks as the top
 ■■
 † **bwang8** 5/10/06 7:42:51 PM EDT: my explanation is pretty bad
bwang8 5/10/06 7:43:01 PM EDT: do you understand?
Quicksilver 5/10/06 7:43:12 PM EDT: enough to go on with the problem
Aznx 5/10/06 7:43:12 PM EDT: I understand it.
bwang8 5/10/06 7:43:16 PM EDT: ok
Aznx 5/10/06 7:44:27 PM EDT: So what should we do next?

Excerpt 4.2.5

of understanding work.

4.2.2. Case Study 2

In the following sequence we analyze as another example of making an assertion, we show how the assertion is designed and made that it is recognized as such. In this case, it is made after the matter of concern is recognized as possibly problematic thus being illustrated by the explanation maker, who is engaged in producing an explanation to a formula offered in response to a question. An explicit assessment for the assertion is not provided but an alternative approach to the one being problematized (i.e. the one that uses "overlaps") to solving the problem is proposed by the third participant. This resolves the conflicts initiated by the assertion.

- Jason** 5/11/06 7:35:45 PM EDT: how did you get it?
137 5/11/06 7:36:23 PM EDT: There are n-1 overlaps here...
137 5/11/06 7:36:24 PM EDT: Wait.
 ■■■
137 5/11/06 7:36:36 PM EDT: Those.
137 5/11/06 7:36:43 PM EDT: And n-1 here:

Excerpt 4.2.6

number of sticks, offered by 137 for the group's assessment: "how did you get it?". The position of 137's post in the sequence of the ongoing interaction suggests that he is probably producing a response to Jason's question. Immediately following his statement, a marker of halting ongoing sequence of interaction "Wait." produced by 137 interrupts the follow of the sequence (that some subsequent actions of producing the explanation are about to come), which holds recipients' attention and at the same time projects that something else off the flow is going to come in the next position. He then marks some sticks on the diagram with scribbles and makes reference to them using a deictic term

However, during the process they engage in presenting and addressing the trouble, they are able to *construct a set of referential resources* for them to talk about and point to (important for understanding work). The referential resource that has been lack from the beginning when bwang presents his strategy and equation gets to be built at this point of time and a clearer explanation of the strategy (as well as the equation) is offered as an outcome of the episode

This sequence of analysis starts with 137's statement where the term "overlaps" is first being introduced (at 7:36:23 in *Excerpt 4.2.6*). The statement comes about 40 seconds after the immediately preceding post, a question by Jason directed to 137 that inquires about a formula that counts the

“Those.” By performing those actions, 137 seems to be oriented to illustrating “overlaps”, showing that he probably has come to realize that the term “overlaps” may not be familiar to its recipients thus further work may be needed the help them understand. The use of deictic term “here”, followed by ellipse in his statement at the beginning also projects some reference is yet to be established. Such projection helps attract the attention of the recipients for actions to come, which turn out to be some drawing actions on the whiteboard: 137 creates scribbles on three horizontal sticks in the middle on the diagram showing a particular stage of growth of the shape that has been created in earlier engagement of the group (*Figure 4.2.6*). The drawing actions are indicated by the three little blue squares in the chat area, as awareness information produced by the system for better orienting the attention of the interactants. The actions are followed by a text post “Those.” which serves to complement the reference set up by the projection. 137 then continues to produce a text post “And n-1 here:”. Prefaced with “and”, the post indicates what has been produced is not complete yet for the purpose of illustration. The “and” preface and a repeat of “n-1” show what’s come is to the next part of the illustration and directs recipients’ attention to actions to be performed. Following the post, 137 performs similar drawing actions on the whiteboard but on the diagram created for a different stage of the growth of the shape and marks the three vertical sticks in the middle that together with the three marked earlier belong to part of the diagram that shows the stage 3 of the growth (*Figure 4.2.7*).

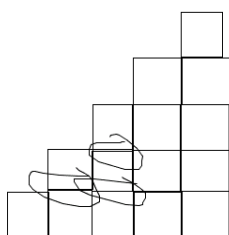


Figure 4.2.6

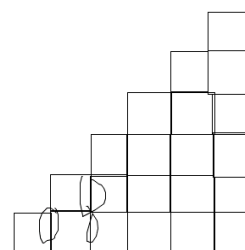


Figure 4.2.7

137’s response to the question and subsequent actions to illustrate “overlaps” suggest that “overlaps” is treated as something appropriate for addressing the inquiry how the formula is derived, i.e. a strategy used to approach the problem. However, the illustration turns out to be problematic for both recipients qwer and Jason, who respectively indicates trouble of some sort. Qwer seems to have trouble with the referent of “those” (Excerpt 4.2.6), whereas Jason produces a complete question – *what do you mean by: “overlaps”* – that makes a request upon 137 for further elaboration on “overlaps”, which is what 137 has been oriented to illustrate. The way the question is designed seems to allocate the accountability of the problem to the presenter 137 that he is being accountable for pointing out what “overlaps” may possibly be referring to. 137 offers an elaboration in the subsequent post that appears to be some reasoning on why the sticks being marked are considered “overlaps”. Now it is the turn of the recipients of the explanation or elaboration to make an assessment.

Jason 5/11/06 7:38:13 PM EDT: are you guys still talking about that formula?

Jason 5/11/06 7:38:22 PM EDT: because i dont think the overlap in the diagrams matters

137 5/11/06 7:38:23 PM EDT: Yeah...

Jason 5/11/06 7:38:36 PM EDT: if you are only calculating the number of sticks

qwertyuiop 5/11/06 7:36:46 PM EDT: those?

■■■■

Jason 5/11/06 7:36:57 PM EDT: what do you mean by “overlaps”

137 5/11/06 7:37:17 PM EDT: They’re counted twice; they belong to two boxes.

■■■■■

The assessment is noticeably delayed: there has been almost one full minute of elapse in the chat during which no posting is made, indicating that something is probably being problematic. Excerpt 4.2.7 assessment to come may be dis-preferred. During the silence, 137 starts to orient himself to some actions on the whiteboard (which do not show as visible on the whiteboard however), showing that he treats his explanation as complete and the prior sequence of addressing the inquiry on the formula is concluded as well. The first post after this extended elapse is a yes/no question from Jason that does not read as directly relevant to the matter of “overlaps” that the group has been oriented to at the first glance. It appears to be a clarification question that inquires about the task they are currently oriented to, presumably the one proposed by 137 which has started this line of discussion at the first place. The post that immediately follows is a continuation which starts with “because”, in which an assertion is made that *problematizes* the approach using “overlaps”. The assertion is however *mitigated* by the preceding question which offers a cause of the trouble introduced by the assertion as the possibility that they are oriented to different topic. It is further softened by a following post that presents an “if” condition that the assertion holds “if you are only calculating the number of sticks”. The question that comes before the assertion now appears to be a setup for the assertion to come. By using a setup question to offer an alternative cause for the trouble and appending with an “if” condition, the assertion is designed to convey in a mitigated way so that the presenter gets to express his opinion with a strong *epistemic stance*, which problematizes and challenges what has been proposed, but at the same time attends to issues such as saving “faces” and *preserving peer relationship* in a peer group.

qwertyuiop 5/11/06 7:39:02 PM EDT: might be easier if you think of each square corresponding to 2 sides-the right and bottom sides, and then add the upper left border
 qwertyuiop 5/11/06 7:39:50 PM EDT: so it's number of squares*2 + ...
 Jason 5/11/06 7:40:04 PM EDT: i don't see how the borders overlap
 Jason 5/11/06 7:40:10 PM EDT: if it's just right and bottom
 t 137 5/11/06 7:40:18 PM EDT: ?
 t qwertyuiop 5/11/06 7:40:32 PM EDT: number of squares*2 + n*2
 t qwertyuiop 5/11/06 7:40:46 PM EDT: overlap?
 t 137 5/11/06 7:41:23 PM EDT: Yeah, that should be right...

Excerpt 4.2.8

order. For example, the sequence could get interrupted for various reasons. Social interaction is messy and often demonstrates irregularity in the local organization and production of it. In this case, the assertion made by 137 does not get explicit uptake, although the pre setup question gets an affirmative answer from 137 (7:38:23). What appears sequentially after Jason’s assertion is a rather long post from qwer in which he offers an alternative approach for counting the sticks to 137’s that uses “overlaps” which has turned out to be the source of trouble. The awareness information in the system shows that Qwer starts typing after half minute or so after 137’s explanation of “overlaps”, which is before Jason’s assertion. We may not necessarily be able to argue that Qwer’s proposal is made to address the conflicts brought up by Jason’s assertion but

We have discussed the procedure involved when an assertion as such is made. It calls for assessment and a dis-preferred (i.e. negative) assessment would put production of an account as the relevant next action. However such procedure of social interaction does not mean that the actions always happen or always happen in that particular sequential

the sequence follows shows that interactionally, it diverts the group's attention from the assertion and no explicit assessment is made as the assertion calls for. The alternative approach, however, is treated by Jason as not different from 137's since he uses it to support his earlier assertion that the overlap does not matter in a reformulated statement at 7:40:04, again followed by an "if" condition in the next post. The reformulated assertion regarding "overlap" receives confusion from both 137 and qwer. The group opts to abandon pursuing the assertion and move on to evaluating the formula derived from qwer's approach.

4.2.3. Case Study 3

The first sequence

In the following excerpt, we show how an assertion is designed to be recognized as such and how it is taken up and dealt with by its recipient(s). In response to an elaborated explanation produced by qwer in regards to "colinear sides", a new term introduced by the presenter qwer, 137 makes a positive assessment, which demonstrates his achieved understanding on the previously problematic matter: "Ah. I see.". He then engages in some drawing actions on the whiteboard that produce some orange segments on top of some lines on the existing diagram (of triangles), resembling the shape of a hexagon (*Figure 4.2.8*). As if the actor is aware that the silence in chat after his assessment may be treated as concluding the prior question-response sequence, the next post from 137 starts with a marker of "show stopper" – "Wait." that is used to project something else off the ongoing sequence is going to come and orient recipients' attention to it. The second part of this post is a *Reversed Polarity Question* (RPQ) (Koshik, 2005), which takes the form of a yes/no question with a preference for an answer that is the reverse of the first part of the question. In this case, the question starting with "wouldn't" conveys an assertion that is the "reversed" of the question, which is, "*that would not work for that one*". Taking into consideration the relevancy of this post in the sequentially unfolding sequence of interaction, it is rather unambiguous that the first deictic referential term "that" refers to the approach of using "colinear sides" that has been the matter under discussion and "that one" is likely referring to the object that has just been created on the whiteboard, which is used as a case of "hexagon", the new problem that the group has been working on. As Koshik puts it, a RPQ "stakes out the epistemic stance" of the questioner. Following the question-answer sequence where the trouble with "colinear sides" has been initiated and an explanation produced, the assertion conveyed by the RPQ problematizes the approach of "colinear sides" that has been explained in the prior sequence of inquiry-explanation. It calls for an affirmative answer, i.e. an agreement, as preferred response (Pomerantz, 1984). If a negative answer is made instead, an account for such negative answer will need to be produced as the next relevant action.

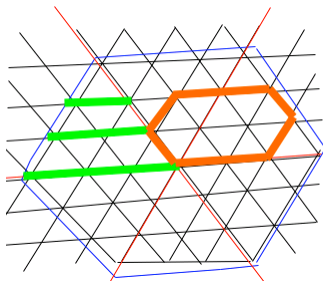


Figure 4.2.8

137 5/16/06 7:30:23 PM EDT: Ah. I see.
 ■■■■■■
 137 5/16/06 7:31:07 PM EDT: Wait. Wouldn't that not work for that one?
 Jason 5/16/06 7:31:12 PM EDT: yeah
 Jason 5/16/06 7:31:15 PM EDT: because that's irregular
 137 5/16/06 7:31:17 PM EDT: Or are we still only talking regular ones?
 137 5/16/06 7:31:22 PM EDT: About

Excerpt 4.2.9

This question from 137 is taken by the third participant Jason (other than the one who has produced the explanation) as an assertion for he offers an *agreement* in the immediately following post. The agreement is supplemented with an account for the assertion – “*because that's irregular*”, with “that” presumably referring to the orange hexagon which has been created by 137 and referred as “that one” in his assertion. In the subsequent post, 137 downplays his assertion by offering an account to consider for the problematized approach to hold true: a possibility is introduced that the discussion is only for “regular ones” and the case of “irregular” one is yet to be discussed (at 7:31:17). Introducing an account for the approach that is being problematized by his own assertion mitigates the assertion by avoiding characterizing the problematized approach as incorrect if the asserted matter holds true. Such mitigated ways of making an assertion to problematize the work presented by others are not surprising for us as analysts to see in a peer group since it is through those ways and actions the members engage themselves in doing such *peer relationship* is enacted and maintained.

However, 137's assertion does not receive assessment from the presenter of the approach that is being problematized. Qwer seems to have been oriented to the next step of the problem solving. The next post from qwer appears shortly (14 seconds later at 7:31:24, in *Excerpt 4.2.10*) after 137's assertion. The rather complex post offers some observations on the pattern of growth, which probably would have taken some time to produce. This marks that qwer has probably diverted his focus of attention to a different topic rather than “colinear sides”. The awareness information in the system shows that qwer has been engaged in typing ever since his post at 7:30:01 where he offers an elaborated explanation of “colinear sides”. From the timing of the production of these postings, it seems likely that the challenge brought up by 137's assertion, which is endorsed by Jason, gets ignored by qwer, whose attention has been devoted to working out the number of sticks for different “side length” of the shape.

The second sequence

The sequence of interaction immediately follows is another example of an assertion, which in this case offers a contradicting result with what has been presented for others to consider. The disagreement later on turns out to be arising from some trouble of “misunderstanding”, for which our analysis shows how it is revealed and constituted as such as well as how it is resolved through the group process. The first line (*Excerpt 4.2.10*) appears to be a report from qwer that presents results of some sort for the group that consist of a sequence of numbers for different “side length”. The ellipse at the end projects the continuation of the sequence growth. Looking back at how qwer explains for

the approach of counting the number of sticks for the new problem of “hexagonal array” at 7:39:01, where the approach is described as “Find the number of sides in one set, then multiply by 3 for all the other sets.”, we can see that qwer has moved on to the next step of their problem solving – “find the number of sides in one set”. By performing this action, qwer treats the previous sequence of question-answer regarding the “colinear sides” as concluded (prior to 137’s assertion we see in *Excerpt 4.2.9*) and his elaboration of the matter as sufficient to address the prior inquiry. When report like this is offered, it usually calls for assessment from the group. But the design of this particular report by qwer does not mark assessment as the next action explicit. The result it is offering does not appear to be something complete or final therefore an alternative next action could be

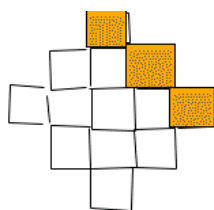


Figure 4.2.9

a further proposition from qwer such as an offering in the form more like a final result. Uptake of qwer’s offering is significantly delayed: the next post that explicitly takes it up appears only more than one minute and half later, from 137 (at 7:32:50). As the awareness information shows, a series of typing and erasing activities from different participants has followed qwer’s post, indicating the problematic situation of producing a reasonable next action. From what we know of the history of this group’s prior engagement, we as analysts are able to recognize that “side length” is a shared artifact which originally has been offered as an approach to solve the “diamond” problem in the previous session and its meaning constructed by the group together. It has been reused in producing a correct solution to the problem by one participant other than the one who introduces it. The “side length” in that case was used to refer to the number of squares on the “side” of the diamond shape (see *Figure 4.2.9*). It is being transformed and reused here by qwer now for their new problem of “hexagonal array”, which could be inferred as referring to the number of sides (of triangles) for the “hexagon” shape. What it is referring to, however, is not explicitly stated. This referential problem turns out to be the source of trouble as we will see in the subsequent interaction where participants are engaged in sorting out the trouble of the “bottom one” brought up by an assertion.

qwertyuiop 5/16/06 7:31:24 PM EDT: side length 1 = 1,
side length 2 = 3, side length 3 = 6...

† 137 5/16/06 7:32:50 PM EDT: Shouldn't side length 2 be
fore?
137 5/16/06 7:32:53 PM EDT: *four
† qwertyuiop 5/16/06 7:33:10 PM EDT: I count 3.
137 5/16/06 7:33:25 PM EDT: Oh. Sry.
← qwertyuiop 5/16/06 7:33:30 PM EDT: It's this triangle.

Excerpt 4.2.10

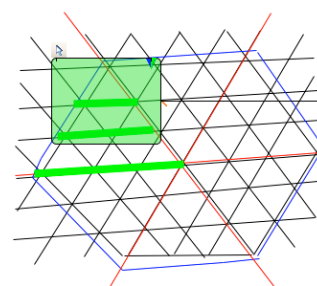


Figure 4.2.10

Following qwer’s contribution that is oriented to a new topic, 137 deletes the orange hexagon on the diagram that he has created in the effort of problematizing qwer’s approach of “colinear sides”, showing that he is orienting himself to the new topic proposed and abandons his previous assertion. There is 16 seconds’ elapse between the next action, 137’s typing in chat, and the last whiteboard action of deleting performed by

137, which opens up the opportunity for possible actions such as qwer's continuation on making a more assessable proposition, elaboration on what has been presented, or inquiry or performing next step from recipients on what's been presented, and so on. The fact that qwer does not make a further action probably shows that it is considered by him the turn for the recipients to act upon what he has presented. The post 137 finally produces appears to have taken 17 seconds, a relatively long time for a simple post like 7:32:50: "Shouldn't side length 2 be fore?" (with a repair in the following post that corrects "fore" to "four", marked by *, an established way of doing repair by users in online chat). The significant delayed post marks that it is likely to be a dis-preferred response, which in this case is an assertion formulated in a RPQ again (similar to the example we have just analyzed) that offers a contradicting result for "side length 2", with explicit reference to qwer's prior post . This RPQ is designed to have an agreement as a preferred answer, such as "yes, it should be". The use of "side length" is treated by 137 as not problematic. His post takes up the use of the term as if its unspecified referent is understood and shared.

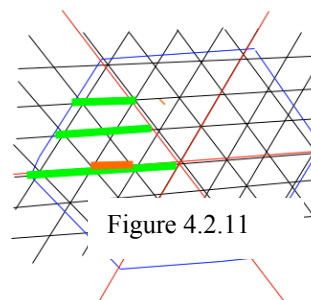
In response to 137's assertion – as indicated by the explicit reference to 137's post, qwer makes a report "*I count 3.*". The report seems to serve to support the result he has presented, which has been contradicted by 137's assertion that it should be 4 instead. The report offers an account for his result by showing that it comes from his counting. It also shows that he has checked his result and confirmed it. The confirmation to the challenged result serves as a negative assessment to the assertion but without making explicit disagreement. The way the assessment is made also avoids directly addressing the issue of choosing a correct one between the two since by making a report on how he gets the result, it does not exclude the possibility that his method or counting could be incorrect. In short, qwer's response to the assertion is designed and delivered to achieve the work of avoiding explicitly disagreeing with the assertion but at the same time demonstrating a strong epistemic stance on the matter. This also puts 137 in the position to produce a counter-account on the basis of his assertion. Qwer's report is treated by 137 as somewhat authoritative, who apologizes for his previous assertion. The assertion is taken by Qwer as indication of some problems of understanding regarding his reported result. He attends the trouble by elaborating on how the result is derived (from counting) by pointing to an area on the diagram which he describes as "this triangle" (*Figure 4.2.10*). By pointing to "this triangle" and referring to "it", he seems to attribute the conflicting results to some referential problem, i.e. they may be looking at different object for the counting activity, and treat making the object of his counting explicit as relevant for resolving the disagreement.

The third sequence

The account qwer produces for the negative assessment he makes to the assertion does not seem to be treated as sufficient for resolving the trouble for that 137 continues to make a second assertion in which he contributes the difference of the two results to the fact that "we're ignoring the bottom one" (*Excerpt 4.2.11*). The assertion again is made in an inquisitive form that sets an affirmative answer as preferred. He then performs some drawing actions by which he creates an orange segment that sits in the center of the bottom green line on the diagram (*Figure 4.2.11*). The actions seem to help make the

reference for “the bottom one” in his assertion. It gets an explicit disagreement from qwer this time, supplemented with an account that seems to treat what has been introduced – “the bottom one” – as not relevant to the difference. This however does not get explicit assessment from 137, who is oriented to offering his observation in the next post

- t **qwertyuiop** 5/16/06 7:33:54 PM EDT: I don't see the pattern yet...
- 137 5/16/06 7:34:01 PM EDT: We're ignoring the bottom one?
- ****
- t **qwertyuiop** 5/16/06 7:34:00 PM EDT: no, 3 is only for side length 2 Excerpt 4.2.11
- t **137** 5/16/06 7:34:02 PM EDT: And I think they're all triangular numbers.



regarding the pattern of the sequence of numbers in response to qwer’s report (7:33:54) following his own statement (7:31:24) that serves to invite others’ contribution. The account made by qwer for his negative assessment of the assertion does not address the trouble regarding the “bottom one” introduced the assertion. In the later sequence of the interaction, we are going to see how 137 tries different ways to introduce the trouble again and how it eventually gets resolved.

The fourth sequence

In the sequence that follows, the group’s discussion is momentarily diverted to dealing with the trouble of “triangular numbers” introduced by 137’s proposal for the pattern (7:34:52). About two minutes later, 137 concludes the insertion sequence and orients the group back to the topic by *reiterating* his assertion: “So are we ignoring the bottom orange line for now?” (see the beginning of *Excerpt 4.2.12*), with an explicit reference pointing back to his original post prior to the sequence on “triangular numbers”. This time the assertion is made in a standard inquisitive form instead of a statement appended by a question mark. It appears to be *mitigated* with the use of “for now” at the end, which indicates the possibility that the current approach is not counting “the bottom orange line” only “for now” but may take it into consideration later. Offering such possibility as account for “ignoring” would avoid making the current approach being problematized sound incorrect even when such assertion receives positive assessment. The referencing to “the bottom orange line” however appears to be problematic that qwer offers a candidate understanding of the referent – “green”? – possibly referring to the green line that the “orange” one is sitting on (see *Figure 4.2.12*). The trouble could be partly caused by the fact that a “line” mathematically does not have a length therefore the “orange line” and the “green line” are not different and refer to the same “line” since they are overlapped with each other on the diagram. This possibility of trouble seems to be recognized by 137, who offers a different description, referring to the object as “segment” instead of “line”. 137 subsequently makes another reference by creating two blue lines as referential objects and referencing to the relation between the referent and them – “parallel to the blue lines”. The assertion again receives a negative

assessment, but no further elaboration or account is produced. The trouble introduced by the assertion is yet to be addressed.

- † 137 5/16/06 7:37:18 PM EDT: So are we ignoring the bottom orange line for now?
- † qwertyuiop 5/16/06 7:37:36 PM EDT: "green"?
- 137 5/16/06 7:37:48 PM EDT: The short orange segment.
- ***
- 137 5/16/06 7:38:05 PM EDT: PArallel to the blue lines.
- qwertyuiop 5/16/06 7:38:05 PM EDT: I don't think so...

Excerpt 4.2.12

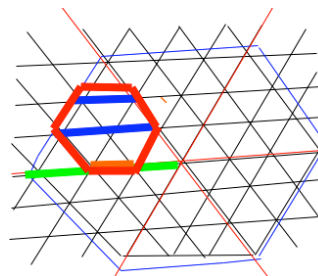


Figure 4.2.12

It is worth noticing that 137 has created a shape of a hexagon within the area of the triangle with the highlighted three green lines, the bottom side of which overlapping with the “short orange segment”. Although the actions are performed during the insert sequence regarding “triangular numbers”, they do not seem to be relevant to the discussion but rather pertinent to the topic of “the bottom one”, considering other drawing actions 137 has engaged in including creating the orange segment, the two parallel blue lines, and now the red hexagon, for which the two blue lines and the orange segment “coincidentally” make up one set of parallel lines. For us as analysts, participants’ actions and their relevancy made available to us at this point seem to suggest that the trouble introduced by 137’s assertion that they are “ignoring the bottom one” probably arises from 137’s orientation to the “hexagon” that he is illustrating, rather than the triangle marked with the original three green lines, which qwer’s approach is oriented to. If this is the case, then “side length 2” refers to the stage as illustrated by this red hexagon (based on the use of “side length” in diamond shape), which can be considered as consisting “3 sets” of parallel lines as well, similar to qwer’s approach to dividing “the triangle” into “colinear sets”. For “side length 2”, the number of the sticks in one set would be four, including the “bottom orange segment”, as 137 has repeatedly trying to assert. Such different orientation which is not seen by the other interactant seems to be the cause of trouble, which we would describe as trouble of “misunderstanding” here. “Misunderstanding” as a member’s matter only gets produced through the work the participants do. It is us analysts’ work to describe how they orient to the trouble and produce the orderliness as well as dis-orderliness. Up to this point, participants 137 and qwer are still engaged in sorting out the trouble and producing shared understanding. In the next few exchanges of posts, 137 resorts to an alternative way of presenting his assertion, which has been rejected but either without an account or the account produced is not considered as sufficient to address the trouble.

The fifth sequence

137 halts the current interaction and poses a question on a seemingly different issue in which he displays his understanding of the overall task they are oriented to for other to check (at the first line of *Excerpt 4.2.13*). This understanding gets confirmation from qwer, who offers a more specific description of the task – “one of the colinear sets of sticks”. The description seems to be offered for the similar purpose of checking to make sure they are oriented to the same thing. The next contribution from 137 is delayed, that

- † 137 5/16/06 7:38:26 PM EDT: Wait, we are counting sticks right now, right?
- qwertyuiop 5/16/06 7:38:48 PM EDT: yes-one of the colinear ets of sticks
- qwertyuiop 5/16/06 7:39:08 PM EDT: oops-"sets" not "ets"
- † 137 5/16/06 7:39:42 PM EDT: So we are trying to find the total number of sticks in a given regular hexagon?
- † qwertyuiop 5/16/06 7:40:18 PM EDT: not yet-we are finding one of the three sets, then multiplying by 3
- qwertyuiop 5/16/06 7:40:40 PM EDT: that will give the number in the whol triangle
- † 137 5/16/06 7:40:51 PM EDT: Then shouldn't we also count the bottom line?

the col Excerpt 4.2.13 ticks". How qwer describes the task is consistent with our understanding of the orientation to the task – the hexagon, rather than the triangle as qwer is oriented to as his explanation demonstrates. Qwer assesses this description of their task as inaccurate – “not yet”, then explains again the current task they are oriented to. The first part of qwer’s explanation (at 7:40:18) of the task however, applies to a hexagon as well, as 137 is oriented to. It is used by 137 as a supporting argument for his assertion that he reiterates in his subsequent post: “Then shouldn’t we also count the bottom line?”. The second part of qwer’s explanation in a following post explicitly states that the 3 sets “will give the number in the whole triangle” – although the referent of “the whole triangle” is not clearly specified therefore could be problematic. 137 offers his candidate understanding for the second part of the explanation and elicits assessment explicitly. The orientation to the “hexagon” that is displayed in 137’s candidate understanding is evaluated as not correct since an alternative is offered as correct – the “triangle”. It is at this point that 137 finally displays his achieved understanding on the matter: “Oh.” in the immediately following post and stops pursuing getting his assertion accepted. Qwer follows his correction “triangle” with a pointing action – making a reference to the area that contains the top left triangle on the diagram and using a deictic term: “this one”. By engaging in the pointing action, qwer shows his awareness that the referent of “the triangle” is problematic for his recipient and more work is necessary to make it explicit.

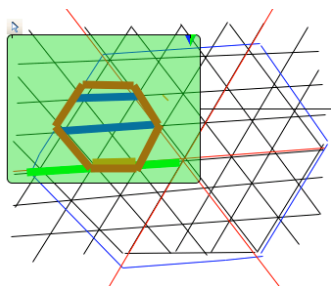


Figure 4.2.13

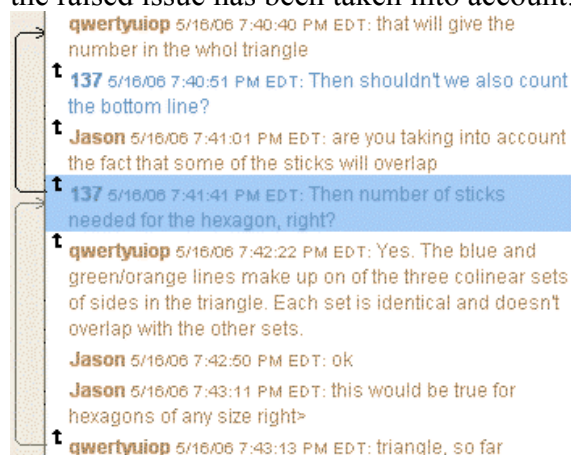
- † qwertyuiop 5/16/06 7:43:13 PM EDT: triangle, so far
- 137 5/16/06 7:43:25 PM EDT: Oh.
- ← qwertyuiop 5/16/06 7:43:26 PM EDT: this one
- 137 5/16/06 7:43:52 PM EDT: Yes, but they will overlap...
- 137 5/16/06 7:44:13 PM EDT: Eventually when you multiply by 6 to get it for the whole figure.
- † qwertyuiop 5/16/06 7:44:30 PM EDT: no, the sets are not colinear with eachother. I'll draw it..
- *****

Excerpt 4.2.14

The insertion sequence

Approaching to the end of this extended sequence regarding the “bottom line” (at 7:41:01), the third participant Jason who has remained silent during the process raises another issue that problematizes qwer’s approach which qwer has been trying to explain

all along to address 137's assertion. The inquiry is made in response to qwer's explanation – with an explicit reference pointing to the second part of the explanation. It is addressed to the author of the referenced post. An assertion is made in the inquiry: that “some of the sticks will overlap” is stated as “the fact”, conveying a strong epistemic stance on this matter he is holding, and it should be taken into account. Presenting in the format of an inquiry – “are you taking into account...”, the assertion is made in a rather softened way: an alternative assertive way could be: “I don't think it has taken into account the fact that ...”. The inquiry is presented as legitimately relevant to the ongoing discussion since no marker of new topic is used. The timing and position of it within the sequence indicate that the third participant Jason has been following the discussion and he also has troubles with qwer's approach of “colinear sides”. Although formulated as a simple yes/no question, the inquiry is received as problematizing the approach that qwer has just offered explanation about: a rather elaborated account is produced following the positive answer made to the question, in which explanation is provided to support why the raised issue has been taken into account.



Excerpt 4.2.15

Jason accepts this account as adequate and proceeds to check the generalizability of the approach that whether it is applicable to “hexagons of any size”, an action that displays his understanding for assessment. 137, on the other hand, acknowledges qwer's explanation but at the same time disagrees with qwer. He makes a contradicting claim that the sticks “will overlap” “when you multiply by 6 to get it for the whole figure”. In response to 137's claim, qwer engages in drawing actions to illustrate, during which 137 explicitly makes positive assessment that he understands. Qwer produces 3 “sets” on the “triangle” which he uses distinguishing colors for each (*Figure 4.2.14*). This illustration of the approach appears to be more complete and more sophisticated, compared to earlier ones that consist of illustrating only one set (e.g. the green lines) or pointing to an area (e.g. the smaller triangle). There is more than a minute elapse following qwer's illustration and text explanation, during which no post appears in the chat. In the following sequence, the moderator steps in asking a question off the current topic and the group attends to it. After this insertion sequence, as shown in *Excerpt 4.2.17*, Qwer orients the group back to the topic by offering a formula for the group to consider that describes the pattern of the series of numbers presented by 137 far back in the chat (at 7:35:59, as pointed to by the explicit reference). It is taken up by both of the recipients,

137 and Jason. The group shifts to the new topic, which marks the completion of the extended sequence focusing on qwer's approach that has been problematized by 137's assertion and later on Jason's, both of which are relevant in the sense they both present troubles of "misunderstanding" with the approach.

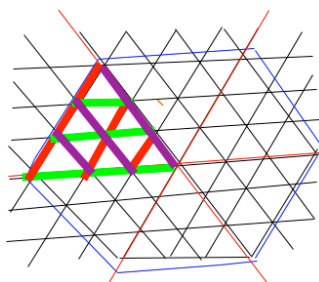


Figure 4.2.13

† **qwertyuiop** 5/16/06 7:52:19 PM EDT: what about: $f(n)=2n-1$ where n is side length
 † **137** 5/16/06 7:53:03 PM EDT: I don't think that works.
137 5/16/06 7:53:18 PM EDT: Howbout just $n(n+1)/2$
Jason 5/16/06 7:53:41 PM EDT: for # sticks?

Figure 4.2.14

137 5/16/06 7:46:34 PM EDT: Oh. I see.
qwertyuiop 5/16/06 7:46:52 PM EDT: Those are the 3 sets. One is red, one is green, one is purple.
 †
Jason 5/16/06 7:47:12 PM EDT: wait-- i don't see the green/purple ones
 †
 † **qwertyuiop** 5/16/06 7:47:40 PM EDT: SO we find a function for that sequence and multiply by 3

Excerpt 4.2.16

Discussion: By articulating step by step his understanding of the task they are oriented to and making it available for assessment, 137 gets the presenter of the approach that has been problematized to produce a different explanation, delivered into parts and specifically in response to his articulated understanding.

4.3. Pursuing an explanation through reports – the preferred structure and its variations

Being able to ask certain kinds of questions regarding a trouble source requires a certain amount of competency. When participants lack such competency, they resort to other methods to present their troubles to recipients and position themselves as peers to mitigate any epistemic differentials.

4.3.1. REA (report – explanation – assessment) sequence

One of the ways that participants introduce troubles to the group is to make a report of their troubles with understanding. Such reports are usually designed to elicit explanation from the recipients. Compared to a request or a question, the features of a report make it less explicit in eliciting a response. When failing to get a response, i.e. explanation in this case, participants could choose to pursue it using other methods or simply drop it. Our interest is focused on the prior situation. Our analysis shows when pursuing an explanation through reports, there often exists an *escalation structure* in the sequential organization of the actions: the moves participants make start with being implicit and less direct and shift to being more explicit and direct, making a response in the next position

more pressing and failing to provide a response would more likely result in interactional trouble.

When someone reports his trouble to the group, an explanation is expected in the next position of move. A preferred structure in pursuing an explanation through reports looks like this (with A and B indicating the interactant who performs the action):

- 1) *Trouble Report (A)* – a declarative (statement) in which something is problematized by a speaker for self or others without specifying the upshot/next position – it is the recipients’ work to figure that out.
- 2) *Explanation (B)* – Report or description, usually in the form of a set of declarative utterances, designed to elaborate, identify or otherwise make evident that which caused a prior trouble.
- 3) *Assessment (A)*

Here is another example of a preferred report/explanation/assessment sequence:

Excerpt 4.3.1

790	Quicksilver	I personally don't get the two flat sides	07.12.22
791	Quicksilver	I don't know how a pyрмаid would do that	07.12.29
792	Gerry	Imagine stacking the blocks in a corner of a room, against the walls	07.13.22
793	Gerry		07.13.22
794	Quicksilver	Oh	07.13.33
795	Quicksilver	I see	07.13.35

At line 790, a report is produced by Quicksilver in which the matter of “the two flat sides” is problematized as not being understood by the speaker therefore is recognizable as a *trouble report*. The report is followed by another declarative statement in the immediately following line that provides an elaboration of the report. The source of trouble is being pointed out as that the problem resides on conceptualizing how a “pyрмаid” would have two flat sides. The trouble report is made as a response to a question posed by bwang in which he problematizes “if it had 2 flat sides” as suggested in the feedback for their last session as a variation of their problem to consider. It is not clear that what is called for in the next position following the report and it is the recipients’ work to figure out what may consist of the next reasonable action for them. In the next 50 seconds or so in which space has been opened up for the opportunities for others to produce next action, no group member follows up on this report. The speaker himself moves on to cleaning up the center area of the whiteboard.

In the following line comes a posting from the session moderator Gerry that consists of an imperative sentence, which gives instruction on actions of building blocks. The instruction is recognized by Quicksilver as an *explanation* produced to address the trouble he reports with understanding a pyramid with two flat sides. An *assessment* to the explanation is given with a change of status marker “Oh” and a declarative, which together indicate some achieved understanding of the matter at hand.

Here’s an example from the data to illustrate this structure.

Excerpt 4.3.2

890	qwer	what about the hypercube?	08.12.22		Proposal
891	137	Er...	08.12.33	Ref. to 890	
892	137	That thing confuses me.	08.12.39	Ref. to 891	Report
893	137	The blue diagram, right?	08.13.00		
894	qwer	can you imagine extending it it 4 dimensions, and a square extends into a grid?	08.13.13		Explanation
895	qwer	yes	08.13.17	Ref. to 893	
896	137	I didn't get that?	08.13.30	Ref. to 894	Assessment
899	137	Ya.	08.13.50		
900	qwer	If you have a square, it extends to make a grid that fills a plane. A cube fills a space. A smaller pattern of hypercubes fills a "hyperspace".	08.15.02		
901	137	The heck?	08.15.19	Ref. to 900	Rejection of proposal
902	137	That's kinda confusing.	08.15.29	Ref. to 900	Assessment/Report

Ethnographic background to the excerpt: At line 890, qwer makes a proposal of a new problem – *hypercube* – for the group (or more accurately, his partner 137, who is the only other member in the chat room, apart from the moderator, because the third member Jason has left early) to consider. This is the second time that this problem is brought to the group to consider. It was first introduced at the end of the last session by qwer but the team opted out for another problem due to the perceived difficulties with understanding the proposed concept of hypercube (see interaction at 8:20:02 at 5/11/06 Jason: *well maybe i'll understand this more if we dealt with 3-d cubes first*). Qwer's proposal in an inquisitive form invites response to it.

Trouble Report: In line 89, 137 makes a post “*Er*” followed by ellipsis that is the text version of the noise that one would make in verbal conversation to express certain emotion, which in this case, to express hesitance and possibly frustration to some degree, or dispreference.

The report is produced in lines 891 and 892 and is followed at line 893 by a question.

These postings are recognizable as a troubles report for the following reasons:

1. The first post (line 891) is a dispreference marker. This expression serves as an opener to a report that comes in the following line: “*That thing confuses me.*”.
2. The second post (line 892) is in the form of declarative in which what the deictic phrase “*That thing*” is pointing to is problematized as confusing to the speaker.
3. The third post (line 893) is a declarative with an interrogative tag that is designed to locate and confirm the troublesome object.

Together, they present some potential trouble with understanding a matter of joint consideration – the hypercube – and initiate the trouble's talk by eliciting some action to attend this trouble.

The report gets an immediate response that comes in the subsequent line from qwer who has started composing that post immediately after the opener of 137's report. One feature of a text chat environment like VMT is that an interactant could monitor the appearing of postings while composing a message so the final production of that message could have taken into account of the existing postings. In this case, although qwer starts composing the message immediately after the opener of trouble's report gets posted, he could be well informed of what 137 makes in the subsequent report so his posting is providing the assistance that the report or the report-opener is calling for. This appears to be a pre-explanation query in a yes/no question form, which explicitly elicit a yes or no answer from 137 to the instructions put forward that are designed to help 137 understand what a hypercube is. **The explanatory sequence** is initiated at this line (894) with such a pre-explanation query about the troublesome object. Qwer then continues to confirm 137's question that the reference to the object is correct. Qwer's query puts 137 in the position of providing a response (a yes or no answer), which in this case would consist of an assessment of his ability in following the instructions provided. A negative assessment is made by 137 in the form of a report: "I didn't get that?". It takes the form of a statement which itself does not constitute a question from linguistic point of view but interestingly ends with a question mark. The deictic reference "that" is made explicit by the use of explicit reference available in the system that points the post to qwer's posting of explanation. By doing this, 137's post 1) offers a negative assessment to his ability in following instructions provided by qwer as a pre-explanatory, instructional move, which at the same time 2) makes a self report of its own in regards to 137's trouble of understanding the matter jointly considered – the hypercube, and 3) calls for some further instructions (or alternative way of doing that in the first attempt) to resolve his trouble that he "*didn't get that*".

This initiates a second round of Report-Explanation-Assessment (REA) sequence, which we try to analyze as follows to further illustrate the structure of sequential organization of the actions involved.

Excerpt 4.3.3

896	137	I didn't get that?	08.13.30	Ref. to 894	Report
897	qwer	I'm having trouble doing that.	08.13.32	Ref. to 894	Ref. to 894
898	qwer	didn't get this?	08.13.45	Ref. to 894	Clarification
899	137	Ya.	08.13.50		
900	qwer	If you have a square, it extends to make a grid that fills a plane. A cube fills a space. A smaller pattern of hypercubes fills a "hyperspace".	08.15.02		
901	137	The heck?	08.15.19	Ref. to 900	Assessment
902	137	That's kinda confusing.	08.15.29	Ref. to 900	Assessment/Report
903	qwer	So, how many planes in a hyper cube lattice of space n?	08.15.43		Explanation 1
904	137	Er...	08.16.05	Ref. to 903	Assessment
905	qwer	instead of "how many lines in a grid of length n"	08.16.07		Explanation 2
906	qwer	does that make any sense?	08.16.17		Elicitation

907	137	No. No offense, of course.	08.16.30	Ref. to 906	Assessment
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This sequence of REA shows a light variation to the basic structure in that there is an insertion sequence after the report which is to clarify the report. A question by qwer is posed clearly in response to 137's report at line 898 by repeating part of the report with modified pronouns: "didn't get this?". So it is directed to the author of the report 137. Substituting "that" with "this" emphasizes the contrast therefore inquires about the deictic reference, which is completed by the explicit reference to the explanation that the report is made on. The report with a question mark is designed to elicit actions as providing explanation while this question that partially repeating the report is designed to clarify the source of trouble that the report is referring to. This yes/no question gets an affirmative answer from 137. The source of trouble reported gets clarified at this point and the next position would be for qwer to take the action that the report is calling for, i.e., provide further explanation. In the next position, qwer does this by providing a rather elaborated statement that consists of three full descriptive sentences. This is taken by 137 as the explanation that he is calling for, who provides an assessment subsequently calling that "*kinda confusing*" and should be turned down as a proposal for the new problem to work on. The assessment serves as a report of the recipient's status with understanding the matter being considered. When the assessment turns out to be negative, it reveals troubles, either unresolved old troubles or new troubles introduced by the explanation, therefore initiates a subsequent sequence of trouble's talk. In our example, 137's assessment revealing his confusion gets qwer to continue his instructional work in which he chooses to pose an instructional question that makes comparison between the current matter and a subject that is considered as familiar to the member being instructed. This third sequence follows the same REA structure with slight variation in that assessment is made to the first part of explanation and further assessment is only provided upon elicitation from the participant who completes the second part of explanation and expects some assessment but does not get any.

Drawing on our analysis, we have come to understand that pursuing an explanation through reports may involve several rounds of report – explanation – assessment during each of which the explanation is reformulated and revised based on the new assessment or report. Each sequence may involve some variations to the basic structure. It is summarized as follows:

- 1) *Report (A)*
- 2) *Insertion sequence*
 - a. *Question or request to clarify the trouble (B)*
 - b. *Response (A)*
- 3) *Explanation (B) (+Elicitation of assessment)*
- 4) *Assessment (A) (If assessment is negative, it is a report of trouble, returns to 1)*

In the second sequence from our example, we have seen that when some one makes a report, it is not always clear to its recipients what the trouble the participant may be having and what assistance it may be calling for, in which case they clarify with the report maker such as asking a question to elicit a more specific report. The clarification process appears as an insertion sequence in the basic preferred structure. The insertion

sequence usually consists of a question-response or request-response pair that may also involve multiple rounds of interaction. We present another example to illustrate such insertion sequence that clarifies and constitutes the trouble initiated in the report.

Excerpt 4.3.4

1	ROB	i'm having trouble understanding the result.	8:49:59	Report
2	AME	what part	8:50:06	Clarification 1
3	KOH	what result?	8:50:07	Clarification 1
4	ROB	to the problem	8:50:09	
5	KOH	ok	8:50:14	8:50:14
6	KOH	what dont you understand?	8:50:23	Clarification 2
7	AME	which part are you having trouble with	8:50:24	Clarification 2
8	ROB	the whole thing	8:50:35	Response to 6 and 7
9	KOH	oh...	8:50:42	
10	ROB	fig. 1 mostly	8:50:57	Response to 6 and 7

At line 1, ROB makes a report that he has trouble “understanding the result” without specifying the source of trouble. “The result” may refer to what the group has worked out as a final presentable matter, which is derived from steps that they have gone through. The report appears to the recipients both AME and KOH rather ambiguous that what the trouble may be residing on: they both produce a “what” question respectively regarding the report, both designed to elicit something more specific about the trouble (as in line 2 and 3). The questions are reformulated into a more complete form in the subsequent lines, treating ROB’s initial report as not sufficient to produce the trouble for them to attend to. AME’s question in line 7 uses a deictic referencing term “which part” to point to the source of ROB’s trouble and calls response from ROB that would consists of a report specifying the source of trouble for them. By responding the questions, ROB indicates that he does not understand or he is having trouble with “*the whole thing*”. The response gets an assessment from one of the questioners KOH “oh...” that appears to be in the form of a dispreferred response and convey hesitance of some sort. Such assessment could also be read as disapproval, meaning that the matter being assessed is considered as not sufficient or expected. In response to KOH’s assessment, ROB produces a more specific report that locates his trouble in a narrower scope to “fig. 1 mostly”. Through this sequence of exchanges, the group is able to probe and establish the trouble one member is having and presents to the group to attend to, which they engage in addressing in the subsequent interactions.

In the VMT sessions with usually three or more members working in a group, a report of trouble can often be made by multiple participants who share similar troubles. In some cases, a report of trouble is echoed by a second participant, who has had the chance to make such report but may have chosen not to articulate the trouble. This is possibly related to the social dynamics of a peer group where there are concerns of maintaining the peer relationship, which could be jeopardized by positioning oneself as less competent member of the group. Once the trouble is articulated by a member, it releases such pressure and other members who share similar troubles may feel more comfortable expressing them. A report that calls for explanation as response by its design is rather

implicit and less direct compared to other interactional methods such as a direct request that is designed for getting some actions as a response or a question that is designed for getting an answer. A similar report made by another member can extend the trouble to a bigger problem for the group to attend to by making it a more pressing issue. This following example involves co-construction of the trouble and elicitation for assessment from the explanation provider.

Excerpt 4.3.5

517	qwer	checking for SideLenght=3...	08.12.03		
518	Jason	works	08.12.35	Ref. to 517	
519	qwer	yes, it works	08.12.36	Ref. to 517	
520	Jason	cool, so should we call this a formula	08.12.52		
521	137	I don't get why though...	08.12.57	Ref. to 519	Report 1
522	Jason	i dont either	08.13.29	Ref. to 521	Report 2
523	qwer	I used your previous method: take the (orange) side; that ² gives part of the shape...	08.14.10	Ref. to 521	Explanation
524	qwer	the rest happens to be a square with a side length of one less, therefore th " $(SideLength-1)^2$ "	08.15.03	Ref. to 523	Explanation
525	qwer	does that make sense?	08.15.10		Elicitation
526	Jason	i get it!	08.15.42		Assessment
527	Jason	clever :)	08.15.43		
528	qwer	137?	08.15.48		Elicitation
529	137	Now I do.	08.15.56		Assessment

At line 521, participant with handle name 137 makes a self report regarding his status of understanding the matter that is jointly considered by him and the recipients. This post uses explicit reference to line 519, where qwer, who presents his work earlier and calls the group to check on, produces a report on the result of his checking work on a proposed formula. By reporting the trouble with understanding, 137's post initiates the trouble's work by eliciting some explanation that could resolve the trouble. The elicitation of explanation is directed to qwer by the explicit reference to qwer's prior post, treating qwer as a local expert on the matter who is expected to produce an explanation in the next position. This report of trouble understanding presented work is echoed by another participant Jason 30 seconds or so later, who has been participating in the check work and proposes the conclusion of the discussion by "call this a formula". The "dual" report produced by two participants expands the trouble to a bigger problem and puts the third participant, the local expert on the matter, into a position to produce an explanation to attend to the trouble. In the immediately following line, qwer takes up the report as made to elicit explanation from him and produces an explanation on how the formula is derived. He continues on producing the rest of the explanation in the following post. The two parts of the explanation correspond to the two parts of the formula thus suggest the explanation is completed at the second post. Now the participants who report the trouble are in the position to provide assessment to the explanation that is offered. In this particular case, the third position of the structure, assessment, is done through elicitation of assessment by the participant who produces the explanation and assessment is made as a response to

the elicitation, which is designed in an explicit question form. This example illustrates the preferred basic structure where a report is made, an explanation is produced, and an assessment is made. Within the basic structure, there are some slight variations including the production of a second report, which seems common in a situation where multiple interactants are involved, and the elicitation for assessment, which indicates that assessment is expected as a reasonable next move.

4.3.2. *The escalation structure – the dis-preferred structure*

When an expected explanation is not offered in the next position (which is not necessarily the immediately following slot as the turn-taking mechanism in face-to-face interaction is distorted in online text chat interaction), participants pursue the explanation by making an escalation move, applying a different method that is more explicit in eliciting a response. This dis-preferred structure is illustrated as follows:

- 1) *Report (A)*
- 2) *No Explanation (B)*
- 3) *Escalation Move (A)*
 - i. *No Explanation (B)*
 - ii. *Go back to 3)*
- 4) *Explanation (B)*
- 5) *Assessment (A)*

Step 3) is a nested structure, where another escalation move is made if explanation is not provided in the next position until the pursued explanation is offered. In the analysis of the following sequence, we illustrate such structure.

At the first line of this sequence of interaction for analysis, quicksilver makes a report on his knowledge status regarding “that thing”. By producing such a report, quicksilver shows that he recognizes “that thing”, whatever it may be referring to, and makes a connection between it and his past experience. By suggesting that he has learned it before but only “forgot how to solve that thing”, quicksilver positions himself as someone who has certain math competency therefore is a competent member of the peer group who

Quicksilver 5/10/06 7:48:58 PM EDT: Ahh... I forgot how to solve that thing...We learned it like two months ago

■■■■

Quicksilver 5/10/06 7:49:09 PM EDT: Could someone remind me

■■■■■■■■

bwang8 5/10/06 7:49:50 PM EDT: i don't know if this equation is right

Aznx 5/10/06 7:50:04 PM EDT: I don't exactly remember either. :P

bwang8 5/10/06 7:50:09 PM EDT: the top n is the highest

Quicksilver 5/10/06 7:50:18 PM EDT: It goes up by one every time because $n=1$ rite?

comes together to work on solving math problems. Although not being in an inquisitive form, the report is designed to be an elicitation or mitigated question in a sense and calls the group to produce an explanation of “that thing” to resolve the displayed “knowledge deficit”. Being a mitigated question, it demands response in a rather implicit manner, which makes it relatively easy to get ignored by the recipients without significant interactional troubles.

By making such a report, Quicksilver 1) *offers a self assessment* in regards to his ability with some mathematical subject – the produced “recursive function” equation – of the relevance to the current discussion, which at the

same time 2) *positions himself* as a rather competent member who has “learned” it before but only forgot by demonstrating his math competency through recognizing the subject and making connection to past experiences, therefore 3) *calls for explanation* of the subject, which is very different work from instructional work that may be required to “teach” someone who does not know anything about the subject. The report thus serves as an initiator of trouble for the group to attend to.

Quicksilver’s report does not get response that is called for: Bwang continues with writing his equation on the whiteboard, as indicated by the awareness information. Quicksilver subsequently makes an explicit request for “reminding work”: *Could someone remind me*. In the next 40 seconds or so, still no response is provided to quicksilver’s report or request. Bwang seems still oriented to producing the equation on the whiteboard. Upon its completion, he supplements with a self-assessment of the produced equation that he is uncertain about its correctness. The completion of the equation and the self-assessment together put other participants, namely, Aznx and Quicksilver, in the position of making an assessment for the produced equation. The next posting appears 14 seconds later is from Aznx that offers a report of his own math ability of the subject: “I don’t exactly remember either. :P”. It could be read as a response to Quicksilver’s earlier request on reminding him how to solve *the* (or a) recursive equation, or a response to bwang’s self-assessment, in either case excusing himself from being held accountable for providing an explanation to remind Quicksilver or an assessment on the equation in a lighthearted way (as suggested by the emoticon of tongue sticking out). Aznx’s report puts himself in a position similar to Quicksilver that he knows about the subject but only does not remember and needs to be reminded of. This self-report however expands the problem raised by Quicksilver into a bigger one, which makes it a more pressing issue for the problem to be attended to.

In the next post, bwang provides some extra information that seems to elaborate on his equation by pointing out “the top n is the highest”, treating the recipients as competent to recognize what it may refer to. This is not read as a response to Quicksilver’s request. It is possible that bwang’s attention may have been devoted to the whiteboard thus he fails to see Quicksilver’s request for explanation. In any case, receiving no response to a question or request, one could simply drop it or choose to pursue the response. In the subsequent line, Quicksilver posts the following:

It goes up by one every time because $n=1$ rite?

The post consists of a statement that describes how equation grows over stages, appended with an interrogative tag “rite?”, which transforms it into a yes/no question. The question can be read as following up the unanswered request in which Quicksilver pursues the response by offering a candidate understanding of the matter being inquired about, i.e. how to solve the equation, for assessment by the group. Such a question makes it more evident that an answer should be coming which means that ignoring it would cause noticeable interactional trouble for the group. On the other hand, designed as a yes/no question, it makes it relatively easy for recipients to provide an answer, compared to a request that demands unspecified work such as to “remind” someone of “how to solve that thing”. The candidate understanding demonstrates what one already knows and calls for assessment. The design of the question displays a preference for an affirmative

answer for which if a negative assessment is provided, the trouble of understanding would be constituted and an account would be called for to explain why the candidate understanding is not correct. This question is taken up by *bwang* in the subsequent post, in which he gives a “No” answer, supplemented with an alternative to Quicksilver’s candidate understanding. The trouble with understanding the produced equation for recursive function is constituted now that results in subsequent actions to resolve it.

Up till now, Quicksilver has appropriated three methods to bring his trouble with “recursive equation” relevant to the ongoing interaction of the group. He starts with making a self-assessment report, followed by a direct request for help, and upon receiving no response to his prior efforts on getting help from the group, then poses a yes/no question that displays his understanding for assessment. Such structure reflects that an inquiry starts with being implicit and less direct, shifts to being more explicit and direct. The interactional effects of the methods for doing such inquiry put on its recipients get stronger and more pressing, therefore harder to ignore. One way of achieving this is to display one’s understanding on a particular aspect of the subject matter and seeks assessment as Quicksilver does at 7:50:18.

Although some methods are structurally more explicit in terms of calling for a specific next position (such as a question calls for an answer or a request calls for a response) than others (such as a report is less explicit on calling a specific uptake), an escalation move, however, can take different forms, be it a request or a question. What defines it as an escalation move is contingent to the local organization of interaction.

4.4. A case study on making a self report to initiate trouble of understanding ⁷

4.4.1. The ethnographic background of the data

The data consists of excerpts taken from chat sessions of Team C in the VMT Spring Fest 2006. This event featured four teams who participated in four consecutive sessions over a two-week period. During the four sessions, there were some changes in the membership of some groups. For example, Team C had a newcomer joining at the beginning of the second session but a participant of the first session did not return. Teams were given the same set of problems, which initially required that they find the patterns of growth for a certain shape of stacked squares made up of sticks. In later sessions, the teams made their own shapes using squares and sticks and explored the pattern of growth of the number of squares and sticks in these shapes.

The first part of Team C’s work that we analyze is from the first of the four sessions. It includes one episode that is split in six excerpts and two complimentary short excerpts from later in the session. Nish is a latecomer who joined about 10 minutes after other participants began working on the problem. Prior to Nish’s arrival, the other three participants had worked out formulas to describe the pattern of growth for the number of

⁷ This case study has been included in Chapter 8: Question co-construction in VMT chats in In (2009) Stahl, G. (Ed.) *Studying virtual math teams*. New York, NY: Springer.

sticks. Thus, when Nish arrived, the other participants were busy discussing their formulas. The moderator made two requests asking the group to bring Nish up to speed, the first of which did not receive much attention from the group members who were engaged in their task at hand. In response to the second request from the moderator, two participants, Jason and David, gave Nish brief instructions on how to reload the previous messages in the chat room. David also provided a summary of their findings, including how they found out the pattern of the number of squares and the number of sticks. They then moved on with the task they were engaged in, which was to write up their findings and post those findings on a wiki to share with other teams. The excerpts we analyze here start about 10 minutes after Nish joins the chat.

4.4.2. Making Differences Relevant: Question Construction

In a peer group engaged in math problem solving, competence—either in doing math, in being a member, or in other matters—is not always equally distributed among participants in an interaction. When differences in competencies become relevant matters among participants, participants use conventional methods to attend to those differences. Indicating a problem of understanding like Nish did at the beginning of the episode (see *Excerpt 4.4.1*) or asking a question are among those methods to introduce differences as interactionally relevant. We analyze the excerpt to show how a particular method is used by participants to make differences relevant to the ongoing interaction. When a member of a peer group explicitly puts forward the issues regarding actors' participation such as competency, discussion on such issues is avoided by participants. This allows the peer relationship to be preserved. The excerpt illustrates how Nish's posting at line 126 brings interactional trouble for the participants and how a *question* is constructed through the interaction.

Excerpt 4.4.1

Line#	Handle	Chat posting	Time	Ref.
126	Nish	just to clarify sumthing, i am not overwhelmingly good at math as u guys seem to be, so it may take me more time than u guys to understand sumthing..	06.45.11	
127	Moderator	can you tell us what's puzzling you?	06.45.44	
128	Jason	are we allowed to post images on the wiki? I could just download TeX real quick and get the summation notation in a small graphic	06.46.07	
129	Nish	the derivation of the number of squares	06.46.12	

At line 126, Nish produces a report in which he (a) offers a self-assessment of his own math competency and (b) appends to this a description of his performance and participation in the ongoing activity of the assembled participants as a consequence of this difference. The fact that this report is a self-assessment made by Nish and the organization of participation is explicitly referenced in it (“*so it may take me more time than u guys to understand sumthing.*”) may have made Nish's posting a problematic matter for the participants. It reifies knowledge relations among participants in that the self-assessment is produced by making comparison of oneself to other actors among the group as a collectivity. The report calls on members of the collectivity to organize their

participation to address the issues—i.e., differences among actors made relevant within it—which involves a discussion about one of the actors rather than about a mathematical matter. This problematic nature of the matter is underscored by the fact that there is a thirty-four second interval during which none of the participants responds (even though Nish’s posting is addressed to all the participants as a collectivity, i.e. “*u guys*”), and no other observable activity happens in the system, either in the chat or on the whiteboard, which is rather a noticeable silence for a chat in a small group like this.

Membership in a peer group—i.e., being a peer in the group—involves entitlements and obligations to act, such as asking a question, responding to a request or producing an account. Entitlements of a member are accorded unless otherwise called into question by specific actions. In this excerpt, Nish could have asked a question regarding his problem, but he chooses to make a report instead. If we take a closer look at the setting where the interaction takes place, we come to a better understanding of why Nish chooses not to ask a question. The session is set up for equal participation of all students. The expectation and entitlement of equal participation are also reinforced by the moderator’s reiterated request for bringing Nish “up to speed” and the group’s effort to summarize what they have done for Nish and to give him directions for viewing their previous discussion in response to the request. As a latecomer, it is natural for Nish to feel the need to participate. However the group is oriented to some current task, and asking a question irrelevant to it becomes a delicate matter since it takes the risk of interrupting the ongoing work. In other words, it is always possible to pose a question during a chat, but it must be appropriately situated. Nish’s question about the group’s previous work is not appropriate to the current interactional context. So Nish must engage in some interactional work to prepare a new context for his questioning.

In such an imbalanced power situation with its asymmetry of social obligations, structuring a report like Nish does is probably done out of consideration of being minimally intrusive yet still sending out the message, “*I’d like to participate.*” It is also a request, negotiating how one can participate and be part of the group. Later in the chapter, we will analyze an excerpt taken from the second session of the same group, which serves as a contrasting case where a newcomer asks a question regarding a similar problem in understanding, as a way to demonstrate how the method chosen by a group member to make differences relevant to the interaction is very much locally situated. One function of Nish’s report is probably to initiate instructional work by eliciting questions from other participants to probe his problem in understanding. Such instructional work may be dispreferred, thus avoided in a peer group in order to maintain peer relationships. Problems of participation may therefore arise, where repair becomes a relevant activity. One way to characterize the posting and the subsequent inactivity of the other participants from an interactional perspective is that there was an interruption in the progression of the interaction. One consequence of an interruption in progress is that something needs to be done to restore it if the interaction is to continue. Problems of progressivity call for repair work of some sort: Nish, whose posting led to the lengthy period of inactivity, would have to produce a next posting, or some other participant would need to do so. Given Nish's initial posting, what a next posting could be and who would produce it are a source of interactional trouble for the participants. In this case, a

next posting is produced by the Moderator who asks, “can you tell us what’s puzzling you?” (at 6:45:44).

This posting in a question form is quite clearly addressed to Nish, showing that the moderator has recognized there might be problem of some sort that Nish has—possibly with understanding—which he is trying to indicate and presumably asking for help from the group. By using “us”, the moderator is acting on behalf of the group. The response that it is calling for is thus designed to be directed to the group as a collectivity. It positions the group as recipients and entitles them to respond to whatever Nish may articulate in the subsequent posting. In other words, the posting from the moderator does the work of recognizing the differences (either in math expertise or understanding) as made relevant by Nish’s report, and bringing the issue up to the group to deal with. It also puts Nish in the position of providing more specific information about his problem.

By responding to the moderator’s inquiry, Nish’s response at line 129, confirms with the moderator that there is some trouble in terms of his understanding of what the group has produced and in particular with “*the derivation of the number of squares.*” Though line 129 is not in an inquisitive form, combined with the moderator’s question that it is responding to, it constitutes a *question* in its own right, articulating Nish’s problem and at the same time indicating the need for assistance and calling upon the group to act: How did the group derive the number of squares? Posing a question of this kind instantiates the epistemic stance of Nish—that he does not know the expression for the number of squares was mathematically derived—in relation to the group, positioning Nish as an actor seeking help from the group, and treating the group as entitled to offer the resource to address the epistemic differences. It is now up to the group to determine what an appropriate response should consist of and to work out among themselves who would actually produce or deliver the response.

4.4.3. How the Differences are Attended to: Response Construction

In reviewing our data, we found that participants attend to differences in math as indicated in a question regarding math topics promptly without interactional trouble, in contrast to the lack of response to differences regarding actor’s competency. Differences in competence may come from a variety of sources, for example, math skills, understanding or experience in the group, just to name a few. It is consequential for the interaction what kind of differences the participants highlight and how they treat them. Our analysis of the subsequent data excerpt (*Excerpt 4.4.2*) shows that the difference made relevant in the interaction is treated by the group as an experience of being in the group while that part of work was getting done, instead of treating it as knowledge or as a conceptual deficit in math. In the postings from 130 to 134, Jason gives Nish a recap of what the group did by providing an *historical account of the group’s work*. How a difference is treated by the group as such is an interactional and procedural matter for the participants. When the difference is introduced by Nish as interactionally relevant to the group, the announcement at the beginning of the excerpt (line 126) is a report regarding his own math competence in relation to others in the group: “*i am not overwhelmingly good at math as u guys seem to be.*” Even though such a report is signaling the need for

assistance, it may not be clear to participants (including the moderator) what the particular problem might be, as shown in the lack of response from the participants and the following intervention from the moderator. How participants treat the differences probably accounts for the discrepancy between what the question may be asking and the response being provided as we take a closer look at the data.

Excerpt 4.4.2

130	Jason	oh	06.46.21	
131	Jason	so you see in the list a column for "N"	06.46.31	
132	Jason	when n=1, we have 1 square; for n=2, 3; and for n=3, 6	06.46.50	
133	Jason	we came up with a formula to find the total number of squares for any number N	06.47.00	
134	Jason	the purpose of the formula is so that you don't have to draw out the squares and count them	06.47.16	
135	Nish	um yes	06.47.39	
136	Nish	i know	06.47.41	
137	Nish	but how did u get that formula	06.47.51	

In the five subsequent postings starting with line 130, Jason produces an account of the group's work as a response to address Nish's problem. These postings start with "oh" as a separate line, which is a marker of displaying his understanding of the request and also indicates there is more subsequent posting to come. He first directs Nish's attention to "a column for 'N'", which is stated in the original problem description, and explained what the group has done: "*we came up with a formula to find the total number of squares for any number N*". The use of the pronoun "we" and past tense (as in "*came up*") suggest that this is produced as an historical account of what the group did earlier in the session, before Nish's joining. However, there seems some disconnect between the group's problem-solving steps provided in the two postings in line 132 and 133. The first one lists the number of squares for N from 1 to 3 whereas the following jumps to stating the result that the group found a formula for "*the total number of squares for any number N*". This leaves out the mathematical reasoning on how the number of squares is generalized to N. These sequential postings from Jason end with a statement of the purpose of the formula: "*so that you don't have to draw out the squares and count them.*" If we pay attention to the timestamp of those postings, we notice that they are being posted in a consecutive manner: there is only a few seconds before the next posting appears.

After the last posting from Jason at 6:47:16, the next posting appears 23 seconds later at line 135 from Nish: "*um yes.*" This noticeable time elapse marks the completion of Jason's production of the response, delivered in five individual postings, and projects subsequent action of relevancy. The fact that there is no uptake by other participants indicates that what Jason has produced may have been treated as being endorsed by the group as appropriate to address Nish's question.

4.4.4. Reformulation of a Question

It is up to the questioner to assess the adequacy of a response to a question (Sacks, 1962/1995). The completion of Jason's production of the response calls on Nish to act upon it. In the following three postings by Nish, "um yes," followed by a separate line, "i know," together with a subsequent question, constitute a *dispreferred* response (Pomerantz, 1984). In a situation like this when a request for help is made and a subsequent explanation (which is rather elaborate in this case) provided, a preferred response would be acknowledging the usefulness of the explanation so that the interaction could progress without trouble. A dispreferred response usually involves extra interactional efforts from the respondent such as providing explanation or an account. In face-to-face interaction, one could use a variety of ways to indicate a dispreferred response, such as frowning, using disapproval or hesitant tone, etc. In chat, there has to be effort made to indicate such, which means a chat message has to be constructed to be read as dispreferred, such as a posting being preceded by "um" in this case. The subsequent "i know" indicates that the response provided has not answered the question because what it explains was already clear to the questioner. This also shows that Nish knows much of what went on in the group, but he is specifically asking for help on a particular matter of mathematics—"the derivation of the number of squares".

A question from Nish, "*but how did u get that formula*" (line 137), with a preface "but" is posed immediately following the two short postings. The dispreferred response consisting of the three consecutive postings constitutes an assessment of what Jason has provided in answering Nish's initial question. The question in line 137 can be seen as a reformulation of the initial one. It is constructed in the interaction among question-response-evaluation using the response and the initial question as resources. If recipients can and do reasonably infer that "i know" refers to the math content of the response, then the reformulated question is distinguishing the mathematical derivation of the formula from a recounting of its role in the past group process.

How does the discrepancy arise between the response provided and what the request for help may be asking for? Nish's initially posed "question" constructed through interaction with the moderator—"the derivation of the number of squares (is puzzling me)"—does not reveal to the group what he already knew. The question could be interpreted as asking about the particular mathematical manipulation of deriving the formula from a series of numbers or the problem-solving steps that lead to the posted formula. The differences could be conceptual—as in lack of certain knowledge—or procedural—as caused by Nish's earlier absence from participation. In this episode of peer interaction, the fact that the group treats the differences as the latter seems to suggest there might be certain preferences in a peer group like this for treating differences as differences in group experiences rather than in personal competencies. Actors won't presume incompetence of any sort unless there is strong enough evidence to make it relevant. In our case, the data in later excerpts show that the group finally assumes Nish's incompetence as relevant and makes it explicit after the interactional troubles have accumulated to a certain point. The organization of participation in the group is consequently changed and the peer relationship is not maintained any more, as we will see.

4.4.5. Doing Situated Expertise: Co-construction of the Response to a Question

In the analysis of *Excerpt 4.4.3*, we show how situated expertise is effected by group members collaboratively—how the group organizes its interaction to attend to the differences and effects repairs when possible or finds ways to proceed when repair turns out to be ineffective.

Excerpt 4.4.3

138	Jason	oh	06.48.00	Ref to WB
139	Moderator	i believe so	06.48.11	Ref to WB
140	Jason	uh, basically you try to find a pattern in the total number of squares first	06.48.12	
141	Jason	we found a formula for that which we'll post on the wiki	06.48.47	
142	David	if you look at the patterns row by row, it's 1 + 2 + 3 + 4 + however many rows there are	06.49.00	

We see that Jason positions himself as the recipient (or one of the recipients) of the question, thereby acting as a local situated expert. He appears to be the first one who picks up Nish's question and provides a response, which is presented in three individual postings. It starts with "oh" as a single posting (line 138), a marker signaling more to come in subsequent postings, which also serves as an indicator of expressing his increased understanding of the question, which his upcoming response is going to address. This line also has an explicit reference to the whiteboard, indicated in the log by "WB". The reference appears as an arrow attached to the message in the chat environment (Figure 4.4.1), which is a feature of this environment that allows users to make explicit reference from a current message to previous chat message or to an area on the shared whiteboard. If we follow this reference of "oh", we can see it is pointing to the "*Formula for total # of squares: $n(1+n)/2$* " in a text box created by the group on the shared whiteboard. The use of the graphical reference here serves to confirm Jason's understanding of the deictic reference made in Nish's question, *that formula*, therefore to establish their shared reference to the object, i.e., the specific formula as the common ground that the question-response interaction is based on. By making the deictic reference publicly visible to the group, it also creates an opportunity for other members' assessment and invites participation from them to help construct a response together.

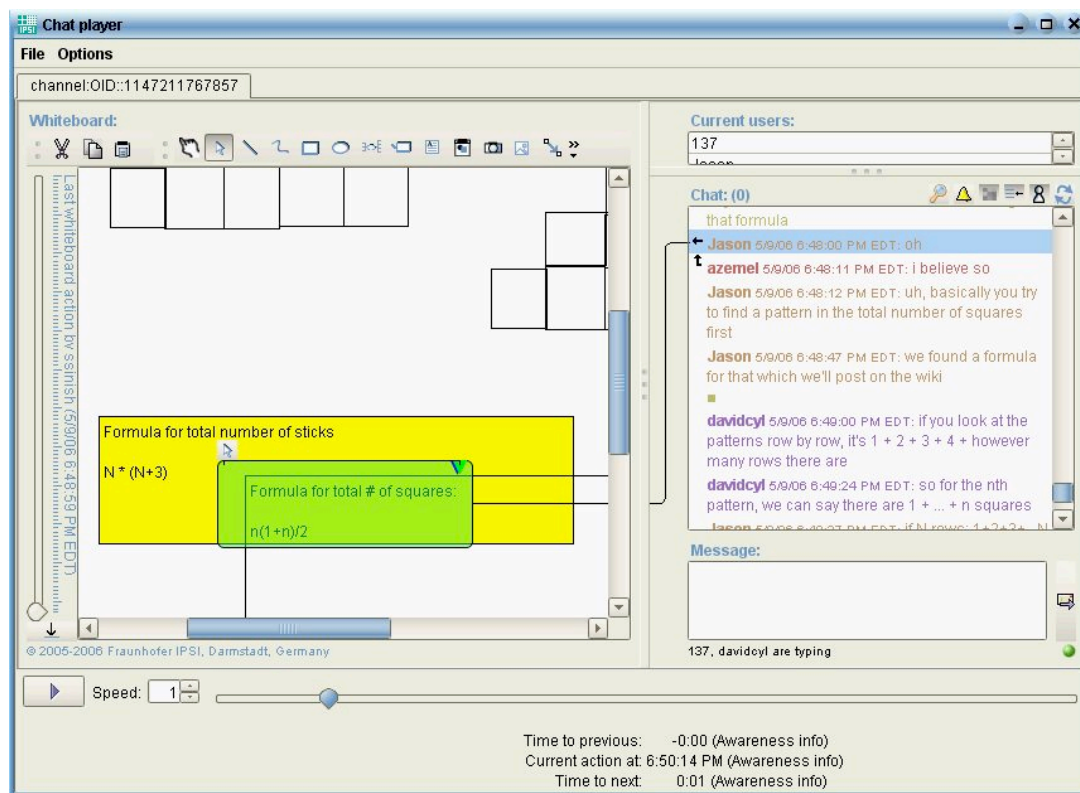


Figure 4.4.1. The session in the Replayer tool.

The use of “uh,” at the beginning of Jason’s next posting (line 140) also displays hesitation of some sort, possibly in the appropriateness of the upcoming content as a response to the question being posed. The response being provided here is presumably some kind of repair attempt that seeks to address the trouble that is made relevant by Nish’s dispreferred reply. It is a reformulation of what Jason previously provided, which the reformulated question is projecting. However, Jason’s response is not particularly different from the earlier response he provided, which the current one is meant to repair: he is reporting the work the group did (*we found a formula*) and also what the group was oriented to (*for that which we’ll post on the wiki*), but not focusing on how the formula, $n(n+1)/2$, is mathematically derived. Such a report may be oriented toward giving the questioner an explanation from a higher-level problem-solving perspective by providing the steps the group has gone through. It is rather interesting that Jason insists on providing a response similar to the previous one just made, which has already been assessed by Nish in his dispreferred response as not being appropriate since he already “knew”. This suggests that actors are conservative of the trajectories they take in interaction, and it requires a considerable amount of work to get people to shift focus onto things other than what they have been working on in interaction. It is routinely the case that people must, over multiple turns at talk and interaction, work out their troubles. The trouble itself may only become evident in the process of working it out, which in our case is demonstrated by the fact that other members jump in later to offer alternative ways to address the trouble. It also seems to suggest a preference that members in a peer group may have in what constitutes an appropriate response to address a newcomer’s

question in order to “catch up”—which is reviewing group experience over providing conceptual math knowledge, as exhibited earlier when the differences are attended to. This may help explain why Nish originally stressed his need for help with math because he wanted an explanation of the derivation of the formula, not the problem-solving steps the group went through that Jason insists on providing.

There is a pause of 35 seconds between Jason’s two separate postings at line 140 and 141, which is an interactionally significant duration in a chat like this. A further, closer look at what happens during this period as we step through the unfolding interaction using the VMT Replayer tool reveals that there is a 12 second interval between when the posting at line 140 appears and the next awareness information “*Jason is typing*” shows, immediately followed by another awareness information “*David is typing*” just 2 seconds later. The finished messages anticipated by the awareness information are posted later in line 141 and line 142. Although Jason’s posting in line 140 is explaining what the “first” step should be, therefore projecting subsequent postings by him on following steps, the 12 second interval during which no observable activity takes place nevertheless indicates the possibility of some interactional trouble and opens up the space for any participants including Nish, the questioner, to address that trouble. It allows the questioner to assess the response or other group members to construct an appropriate response to the question together. David offers a way of addressing the question as an alternative to Jason’s response, implying that there may be another relevant kind of response, different from the one Jason has produced.

Excerpt 4.4.4

143	David	so for the nth pattern, we can say there are $1 + \dots + n$ squares	06.49.24	
144	Jason	if N rows: $1+2+3+\dots N$	06.49.27	
145	Jason	so then we incorporated the formula for finding the sum of an arithmetic series	06.49.57	
146	David	there's a formula for finding the sum of consecutive integers, which (when starting from 1) is: $n(n+1)/2$	06.50.12	
147	137	so you use gaussian sum to get $n(n+1)/2$	06.50.17	Ref to123
148	Jason	that's it	06.50.25	Ref to146
149	David	and as Jason said, it works for arithmetic sequences in general	06.50.35	

David starts in *Excerpt 4.4.4* by describing how the pattern of the number of squares grows “row by row” in relation to the number of rows. He then continues to present how the pattern is being generalized to the nth, which is very similar to what Jason posts in the following line (144) that appears only 3 seconds later. Jason’s posting “*if N rows: $1+2+3+\dots N$* ” does not stand alone as a meaningful and coherent statement if not read together with David’s posting at line 142. It fits seamlessly into the sequential unfolding of the posting just as David’s subsequent one does. When we replay the session in real time, the awareness information in the system shows that Jason started composing his message after David’s first one was posted and while David’s second posting was still

being composed. Analysis of the sequential relation of messages suggests that line 144 posted by Jason is built on David's first posting.

This excerpt displays an instance of how a group engages in doing situated expertise collaboratively by taking up and building on each other's postings and endorsing other's contributions. Jason and David respectively present that there is an existing formula ("*for finding the sum of an arithmetic series*" or "*for finding the sum of consecutive integers*") ready to use, which they "incorporated", as stated by Jason in line 145. David also explicitly provides the formula: $n(n+1)/2$. This contribution is similarly made by the other participant, 137, in the next line that comes just 5 seconds later, where he refers to the formula as the "*gaussian sum*" and also presents the formula explicitly.

David's statement about the formula in line 146 is endorsed by Jason: "*that's it,*" with reference pointed to it using the reference tool (line 148). In his subsequent posting, David also explicitly endorses Jason in line 149 using explicit reference "*as Jason said*" and direct quote with slightly changed wording, i.e. arithmetic sequences in general vs. an arithmetic series. From line 142 to 149 within the period of one and a half minutes or so, the postings from three different participants, namely Jason, David, and 137, align with and build on each other. Together, they construct a rather coherent and complete explanation, at least from the three question recipients' perspective, in response to Nish's question.

4.4.6. How Making the Relationship Explicit Changes Participation

In our case, the group completes the construction of response to the posed question. The completion is marked by David's endorsement of Jason's explanation regarding the formula and the noticeable 16 seconds elapse that follows where no more posting from the three participants is being made. The completion of the question-response pair puts Nish, the questioner, into the position of reacting to the response provided, e.g. making an assessment of it. Nish's response does not come out until 16 seconds later in a very brief form, displaying great hesitance and uncertainty: "*hmm...*" Again, Nish presents a dispreferred response to the proffered explanation. The hesitation marker posted at line 150 of *Excerpt 4.4.5* prepares recipients for the initial indication of uptake at line 151, "*isee,*" and the possible production of a contrastive beginning with "*but ...*" (as we saw earlier, at line 137). Nish does not produce a contrastive posting. From the Replayer tool, we notice that Jason starts composing his message about the same time as Nish starts composing his reply, which he posts at the same time as Nish's second short acknowledgement "*isee*".

Excerpt 4.4.5

150	Nish	hmm...	06.50.51	
151	Nish	isee	06.50.56	
152	Jason	on a side note, you'll be doing stuff of similar sort next year in Algebra II	06.50.56	
153	Nish	thanks	06.51.01	
154	David	ok so let's finish the problem	06.51.11	

It may be the case that Jason's post at line 152, "*on a side note, you'll be doing stuff of similar sort next year in Algebra II,*" was produced and posted in such a way as to circumvent further specification of Nish's query. Another feature of this post at line 152 is that it (a) problematizes Nish's math skill level and competence (as indicated by the remark that Nish will not be exposed to the kind of problem they are working on until the following academic year) and (b) makes the matter of Nish's competence available as a matter of public concern to all parties to the interaction. Nish thanks the group promptly without further comments. David then orients the group to the business that they were working on prior to this whole question-response sequence by proposing the task "*ok so let's finish the problem.*" Nish does not challenge this bid to move on and stops asking further questions regarding the same topic.

The most notable feature of this last portion of the sequence is that there is a shift in topicalization from the mathematics to the skill level of the participant. This constitutes a change in the organization of participation among members that, as subsequent interaction displays, changes the nature and distribution of entitlements, obligations, expectations, etc., among participants. One question left for us to wonder is how such noticeable change of the organization of participation happens. Here we offer explanations from a perspective combining conversation-analytic and peer-group-interactive approaches.

In their response to Nish's question, the three participants treat the formula $n(n+1)/2$ as something already existing that has been "*incorporated*" (in Jason's words) into the construction of their problem solution. By offering this as established knowledge, they assume this knowledge is available and accessible to all, including the questioner. That there were questions about the formula does not mean necessarily that the questioner is incompetent, at least initially. It is only when others have attempted to respond and these responses (a) are deemed by respondents to be adequate ways of addressing expectable troubles with respect to the formula, but (b) do not resolve the questioner's troubles, that an alternative source of the trouble may be investigated or proposed to account for the apparent failure of the responses to resolve the problem. In this case, Jason presents the fact that Nish has not studied this material and cannot be reasonably expected to competently understand it.

Up till now, the differences made relevant by Nish's first statement and subsequent question have been attended to by the group as differences in situated, local expertise. The participation and interaction have been organized around addressing the differences

at hand as topical, i.e., mathematical matters rather than issues of personal competency. Jason’s posting in line 152 however made the issue of relationship itself—i.e., a person’s competency or incompetency—a matter of concern. By saying that Nish will “*be doing stuff of similar sort next year in Algebra II,*” Jason comments on Nish’s studied math preparation, which interactionally serves as a mechanism to shut down this line of discussion. The peer relationship is not maintained anymore, which means certain entitlements of being a peer no longer exist, such as asking a further question regarding the same topic. Such a break down does not however necessarily mean that the peer relationship is never to be restored. In fact, there are ways a member like Nish in this situation may try to establish the peer relationship again.

In the rest of the session, Nish remains silent for most of the time except at one point (about 6 minutes after his last posting in line 153), when he poses a very carefully phrased question about what a summation is (*Excerpt 4.4.6*, line 175). This probably is an attempt made by Nish to get engaged in the ongoing discussion of the group as a way of trying to maintain the possibility of participation and to re-establish the peer relationship. We also see that the question is posed in an artful way of “bracketing” the relationship issue by making the competency issue explicit by the questioner himself. By starting the question with a self-conscious statement “*hope this doesnt sound too stupid*”, the questioner is thus minimizing the chance of a similar judgment being made by the recipients of the question, i.e., the peers in the group.

Excerpt 4.4.6

175	Nish	hope this doesnt sound too stupid, but wuts a summation	06.56.58	
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(two lines that are not relevant to this thread of discussion are omitted here)

177	137	The sum of all terms from a to b	06.57.34	Ref to 175
178	Jason	http://en.wikipedia.org/wiki/Sigma_notation	06.57.36	
180	Jason	don't worry Nish, you'll learn all about it next year	06.58.11	

This question is responded to by participant 137 with a direct answer, “*The sum of all terms from a to b*” and also by Jason with a URL pointing to a Wikipedia article, which presumably contains the information to answer Nish’s question. Following his response to Nish, Jason also makes a comment similar to the one he made earlier that addresses the personal competency issue (but not the topic of the question itself): “*don’t worry Nish, you’ll learn all about it next year*”. The way the question is taken up by Jason—by providing a pointer to the resource rather than an answer to the question—shows the change of the participation within the group, besides what has been made evident by Nish’s lack of participation and his discreetly constructed question. Making the issue of incompetence explicit again shuts down Nish’s chance of getting involved in the group discussion and re-establishing the peer relationship. As a matter of fact, Nish remained silent through the rest of the session until near the end. After the three participants left the chat, which is approximately fourteen and a half minutes after Nish’s question on the summation, Nish posts the following: “*sorry bout holdin u guys up*” (at 07:12:24). When the moderator thanks him, Nish seems puzzled and is not sure whether that is a compliment (*Excerpt 4.4.7*).

Excerpt 4.4.7

273	Moderator	thanks for slowing them down and getting them to explain	07.13.16
274	ssjnish	?	07.13.27
275	ssjnish	was thqat supposed to be a compliment...?	07.13.46

Nish's self disclosure of his feeling again confirms that the way the relationship issue was made explicit as a matter of interactional concern proved consequential for the subsequent organization of participation in the group.

4.4.7. A Contrasting Case

Now we will provide a contrasting case in order to reveal how participants choose methods for making differences in understanding, expertise, etc. interactionally relevant. This illustrates how a question can be constructed to indicate the need for assistance while at the same time demonstrating the questioner's competence of being a member. In this episode of interaction, a newcomer to the group poses a question regarding the same formula in the data we have previously seen, and a response is provided that turns out to address the question properly without any observable interactional trouble.

Excerpt 4.4.8 starts near the beginning of the second session by the same group. Jason and 137 have joined the session, waiting for others including Nish and David to come. A newcomer Qwer who was not in the first session has just joined. In response to the moderator's request to "*bring Qwer up to speed*", Jason briefly describes what the group did in the last session and orients the newcomer to the resources in the environment including the formula, the discussion and the online wiki.

Excerpt 4.4.8

333	Jason	ok, so with this aside-- i guess we should discuss our feedback from the last session	07.18.07	
334	Moderator	make sure you bring Qwer up to speed	07.18.34	Ref. to 333
335	Jason	ok	07.18.41	
336	Jason	for the problems last session, we came up with formulas to find the values for the columns	07.19.35	Ref. to 332
337	Qwer	in the view topic thing?	07.20.02	
338	Jason	You can see them to the left of this text; our formula for the total number of sticks or squares for any number N is given	07.20.03	
339	Jason	yes	07.20.09	Ref. to 337
340	Qwer	ok	07.20.12	
341	Jason	that was the problem we were given	07.20.17	
342	Jason	remains of our discussion is on the whiteboard and online wiki	07.20.39	

About three minutes later, Qwer poses a question regarding the formula “*how did you get $n(1+n)/2$.*” That comes after some account of mathematical reasoning steps, which are composed together within the same posting (line 345, *Excerpt 4.4.9*). A response is then produced and provided by Jason. It starts with Jason’s signature maker “oh” just seven seconds later in a separate posting as an opener to his upcoming explanation that consists of two parts: a sentence on what the formula is (i.e., *for finding a series of consecutive numbers*) and a mathematical equation that demonstrates this notion. Participants, including both the questioner and the respondent, then move on to other topics about some newly introduced features of the chat environment, which is not included in the log here. No further problems or issues are raised and the response is treated as appropriate in addressing the posed question. This marks the completion of the question-response interaction, which only takes about half a minute.

Excerpt 4.4.9

345	Qwer	$n=3$ is $3+2+1$ squares, $n=4$ is $4+3+2+1$ squares... how did you get $n(1+n)/2$	07.23.35
346	Jason	oh	07.23.42
347	Jason	that's the formula for finding a series of consecutive numbers	07.23.53
348	Jason	$1+2+3+4+\dots+n = ((n)(n+1))/2$	07.24.08

By reviewing the data of the two episodes of question-response interaction, we notice some significant differences in the organization of participation in the group interaction. First of all, the two questioners used different methods to introduce *differences* to the group interaction: one makes a report regarding his own competency in math while the

other asks a question regarding the math topic in a straightforward way. In the second episode of interaction, Qwer is a newcomer to the group who joins right at the beginning of the session. The group is still coordinating to get ready for working on particular task of doing math. The expectation of participating, presumably already understood by the participants—also stressed by the moderator’s request to “*bring Qwer up to speed*”—makes it legitimate for the newcomer to ask a question, particularly about problems of understanding the group’s work in the previous session. There is little danger of interrupting or deviating the group from its work flow, as compared to the first case we analyzed. Qwer also has more time to focus on catching up to the group’s work without worrying about keeping up with the current discussion on math like Nish had to do. This perhaps helps with his understanding of the work, thus increasing his ability to construct an appropriate question.

Secondly, as shown in the data, each method results in a particular way that the subsequent participation is organized. In the first case, the self-assessment report introduces significant interactional trouble. A question only gets produced with the intervention from the moderator. It takes several turns and tremendous work for the group to finally work out the troubles among themselves and complete the question-response. At the end, the issue about the questioner’s competency is raised and made explicit, which causes the questioner to be excluded from the group as a peer. In the contrasting case, there is no observable interactional trouble. An appropriate response is provided to the question, and the questioner is treated as a full-fledged member of the group in the subsequent interaction in the session.

Finally, the way the question is produced is quite different in the two cases. Nish’s initial question “*the derivation of the number of squares (is puzzling me)*” lacks any indication of what he already knew. In contrast, Qwer shares with the group what he already understood through a description of the math reasoning in the problem-solving steps before posing the question. What the question could possibly be asking is made quite clear by ruling out other possible readings of it. By doing this, Qwer also demonstrates his competency of understanding the mathematical work and being a member of this peer group. The entitlements of being a peer are enacted in and as the ongoing participation. For instance, in the early interaction Qwer has with Jason, he is being responsive to Jason’s effort of orienting him to the available resources in the environment, and he shows his engagement in the process. All of these allow the peer relationship to be preserved.

4.4.8. The Interactional Emergence of a Question

As revealed in the analyzed logs, in an online collaborative context like VMT chats, questions are not simple, well-defined queries for information, but situated moves within the group process. For instance, Nish’s question about the formula goes through several steps to emerge. As a latecomer, he does not pose the question in the middle of the group’s discussion on the problem. Instead, he makes a report regarding his own math ability in comparison to others in the group, which builds the context of asking a question. We have seen that the moderator solicits a question from Nish in response to the report.

Nish's answer to the solicitation serves as a question to the group. The *question* is thus co-constructed through the interaction among the group, including the noticeable silence after Nish's initial report and the intervention from the moderator as a consequence. The meaning of the question is interpreted interactionally: Jason offers the history of what the group did as a perceived appropriate answer. The answer gets rejected by Nish, who subsequently reformulates the question. Reformulation of the question draws on the answer offered as well as the initial question as resources, which help eliminate other possible interpretations of its meaning. The group engages in a collaborative effort of building a response to the question. Their response is offered and considered by them as appropriate in addressing the question. However, the questioner, Nish, provides a dispreferred reaction, treating the offered response as inadequate. The group respondents react by introducing another source of trouble, the incompetency of the questioner, and make this relevant to the group interaction. The consequence of this is that Nish is effectively shut out and the peer relationship is dissolved. In summary, a question emerges through the interactions of the group and goes through several steps; in each step, the meaning of the question is re-interpreted interactionally and its consequences are played out.

4.5. Other interactional methods for introducing troubles

Apart from making a report, there are a range of other methods that participants use to introduce troubles when lacking competency of producing a question. One way we have seen in our previous analysis is to present what one knows as a way to elicit information on what one does not know without asking a question explicitly eliciting information about or explanation of the matter (see Section 4.1.2). In this section, we present our analysis of two other methods: 1) recipient with trouble of understanding engages others in the group to elaborate so opportunities may rise for putting out a competent inquiry; and 2) presenter initiates understanding work by explicitly eliciting report of understanding status from recipients when they fail to uptake the work presented.

4.5.1. First method: engage others

In a peer group like VMT groups, members are expected to have certain competencies that entitle them as an equal contributor of the group. When there is trouble of understanding, it can be a delicate matter for the members to bring it up to the group thus needs to be dealt with carefully and skillfully, as we have often observed in the VMT sessions. Asking a question regarding some troubles of understanding often does the work of positioning the questioner as less knowledgeable or less competent in the situated local interaction, and at the same time positioning the addressee as one with stronger epistemic strength and in the position of providing information to address the knowledge deficit. Those interactional consequences can pose threat to member's competency that is related to maintaining the peer relationship. Such concern becomes even more acute when a participant does not know enough to ask a competent question. Knowing how to ask an appropriate question for addressing the troubles of understanding requires certain competency from the questioner too. When not having such competency yet the trouble still needs to be addressed, it is a practical matter for the participant to deal

with. In the VMT sessions we have analyzed, we have observed that there are various interactional methods participants resort to in order to introduce troubles to the group other than asking a question so that such potential breach of the expectation of peer competency could be avoided. This particular case we are going to look at involves two of such methods:

- 1) defer the asking of a question to later so opportunities may rise for putting out a competent inquiry, and
- 2) prompt another participant to ask a question by holding the participant accountable for producing a self report on his understanding status.

This sequence of interaction takes place at the very beginning of the first session for Team B, right after the moderator orients the three participants to the environment as well as the task they are set to do. One participant with handle name *bwang8* (here since *bwang*) presents to the group his approach to solving the problem of “getting the total stick” and a math expression as the tentative result. This makes uptake of the proposal of some sort the next relevant action, such as making an assessment, performing the next step in the problem solving trajectory as projected by the proposal, both of which would display understanding of what has been presented, or eliciting elaboration or explanation when having troubles of understanding the relevant matter. However, in this case, we see how participant *Aznx*, being in the position to respond to the proposal, however, methodically and skillfully avoids performing any of the implicatives but changes the holding of the floor of “speaking” (Sack, Schegloff, & Jefferson, 1974). The inquiry to elicit explanation on the approach and the formula is only produced later in the sequence rather as a result of co-construction of the interactants as the interaction unfolds. Through our analysis, we show how participation is organized as a way of setting up the initiation of trouble of understanding regarding what has been presented.



Figure 4.5.1

```

Aznx 5/9/06 6:32:04 PM EDT: Aditya, you there?
bwang8 5/9/06 6:32:05 PM EDT: you can divide the thing into
two parts
█
Aznx 5/9/06 6:32:10 PM EDT: Let's start this thing.
██████████████████████
t Quicksilver 5/9/06 6:32:38 PM EDT: my computer was
lagging...What are we doing?
Aznx 5/9/06 6:32:49 PM EDT:
http://home.old.mathforum.org/SFest.html
t Quicksilver 5/9/06 6:32:58 PM EDT: what are the lines for?
Aznx 5/9/06 6:33:01 PM EDT: go to view topic
bwang8 5/9/06 6:33:05 PM EDT: so you can see we only
need to figur one out to get the total stick
Aznx 5/9/06 6:33:09 PM EDT: read the problem
bwang8 5/9/06 6:33:32 PM EDT: 1+2+3+.....+N+N
bwang8 5/9/06 6:33:38 PM EDT: times that by 2
Quicksilver 5/9/06 6:33:40 PM EDT: Never mind I figured it
out..
  
```

Excerpt 4.5.1

Bwang starts with making a text post at the second line of the sequence we are analyzing here (see *Excerpt 4.5.1*), in which a way of operating some object “the thing” is offered

that is described as “divide the thing into two parts”. With the pronoun “you” and use of “can”, the post is designed as offering a suggestion of some sort to the group. This at the same time conveys the readiness of the suggestion to be made in the sense that it is not constructed as involving the group such as using “we”, which usually is used to engage exploratory work and work together to figure out how to approach the problem. The referent of “the thing” is treated by bwang as known to the recipients, which presumably is something from the problem description that they are supposed to have access to and have read by now. This post sets up for the presentation of the approach, projecting more actions to follow that elaborate on the description that is just provided. Bwang then performs a series of drawing actions on the shared whiteboard that result in the construction of figure X. Following the drawing actions, he makes another text post (at 6:33:05) that builds upon the prior actions with “so” prefacing in which he furthers the proposal by specifying what the group as a collective “we” need to do and characterizes the proposal as “to get the total stick”. This text post is clearly referring to the figure constructed on the whiteboard that consists of two sets of sticks, one vertical and one horizontal. After a slight pause, he offers a math expression supplemented by a post in the immediately following line, which seems to be the result of performing the actions described in his prior post – “we only need to figur one to get the total stick”. While bwang is engaged in the series of actions that are organized to present his approach to “get the total stick” and the result derived from that, the other two co-participants however are busy dealing with some other work: Aznx checks the presence of the other member of the group – Quicksilver – being referred to as “Aditya”⁸, who subsequently reports some technical problem he has had and elicits help from the moderator on orienting him to their task for the session. Aznx then provides instructions to Quicksilver on getting access to the problem description.

Aznx 5/9/06 6:34:01 PM EDT: Can we collaborate this answer even more?
 Aznx 5/9/06 6:34:05 PM EDT: To make it even simpler?
 bwang8 5/9/06 6:34:15 PM EDT: OK
 Aznx 5/9/06 6:34:16 PM EDT: Because I think we can.
 bwang8 5/9/06 6:34:50 PM EDT: $((1+N)*N/2+N)*2$
 bwang8 5/9/06 6:34:58 PM EDT: that's the formula, right?

Excerpt 4.5.2

The fact that bwang stops doing more actions after his last line of the three consecutive posts marks the completion of his proposal. The two recipients thus are positioned to act on what has been presented. It is not until 6:34:01, more than 20 seconds later after the last post of bwang, that Aznx makes a post that shows he is finally attending to bwang’s actions. The delay of uptake to bwang’s proposal shows there might be some interactional trouble, for example, that arises from the recipient not being able to make assessment or perform next step as set by the proposal. Considering that the two

⁸ This name calling suggests that the two participants Aznx and Quicksilver may know each other in real life and they are aware of each other’s identify in the session held in a virtual environment where participants are anonymous with handle names they choose. This turns out to be the case as suggested in the data of later interaction where Aznx reports to the group some technical trouble that Quicksilver has in getting into the online environment.

recipients, Aznx and Quicksivler, are both oriented to a different track of activities while bwang is presenting (and illustrating) his proposal of an approach, it is probably not surprising if they are not following bwang's actions because of the diversion of attention, resulting in troubles of understanding what has been presented. This indeed appears to be the case as displayed in the later sequence of interaction (which we will show in our analysis shortly). The trouble recipients have regarding understanding bwang's proposal, if any, is yet to be introduced and constituted as such at this point. However, in the next action, we do not see explicit initiation of such trouble, but instead a proposal of activity, i.e. "collaborate this answer even more", is made by Aznx, which seemingly serves to engage the group as a collectivity. The proposal is extended by the next post in which a specification of the task proposed is provided – "to make it even simpler" and later ensured for its feasibility by the proposal maker – "Because I think we can." It allocates participation in the group by changing the holding of floor, that is, whose turn is to "speak". When bwang finishes presenting his approach and result derived using the approach, it is the recipients' turn to perform uptake of some sort, such as offer an assessment. By suggesting that "we collaborate", Aznx's proposal shifts the floor of interaction by opening the selection of turn of "speaking" to all members in the group. A closer look at the design of Aznx's proposal reveals that the result in the form of math expression presented by bwang is being treated as an "answer" to the problem, showing that both the result and the approach used to derive it are treated as correct and accepted. However, there is no evidence in the interaction at this point whether such acceptance is based on achieved understanding of what has been presented since there is no display or demonstration of such. Rather, as we have suggested earlier, there seems likely to be troubles of understanding instead. Aznx's action of proposing a next task and accepting the presented work as "answer" nevertheless presumes his competency of understanding the work and preserves the progressivity of the ongoing problem solving as has been leading by bwang. So far what bwang has presented is treated as unproblematic.

bwang8 5/9/06 6:34:50 PM EDT: $((1+N)^2/N^2+N)^2$
 bwang8 5/9/06 6:34:58 PM EDT: that's the formula, right?
 Aznx 5/9/06 6:35:15 PM EDT: How did you come up with it?
 bwang8 5/9/06 6:35:16 PM EDT: for total sticks
 ↑ bwang8 5/9/06 6:35:34 PM EDT: is a common formula
 bwang8 5/9/06 6:35:40 PM EDT: formula
 Aznx 5/9/06 6:35:46 PM EDT: Yeah, I know.
 bwang8 5/9/06 6:35:59 PM EDT: and just slightly modify it to
 get this

Excerpt 4.5.3

The proposal is accepted by bwang, who then self-selects the turn after 8 seconds silence and take quite some time to produce a math expression that he refers to as "the formula" and explicitly elicits assessment from the group. The elicitation is formulated as a statement – "that's the formula" – appended by an inquisitive marker "right?" that sets an affirmative answer, i.e. a positive assessment, as the preferred response (Pomerantz). Being explicitly held accountable for making an assessment to "the formula" presented, Aznx subsequently produces a question in the next turn (at 6:35:15) that is designed to elicit explanation on the process or underlying reasoning of the work presented, or in

other words, instructional work. It allocates the obligation of doing such instructional work to bwang, which in this case, does not get produced but is minimized to referring to some “common” knowledge that would not require any instructional work. In a post that appears about the same time with Aznx’s question, bwang does a repair to his prior posts, clarifying “the formula” is for total sticks. In the period following the question we observe quite some typing and erasing activities between the two interactants Aznx and bwang (as the awareness information shows) before bwang produces a response to the question (6:35:34). It uses the referencing tool in the system to point to part of his math expression a few posts back, i.e. “ $(1+N)*N/2$ ”, and describes it as a “common formula” (as repaired in the immediately following line). Produced as an answer to Aznx’s question, the action locates the source of trouble to be lying at the latest step where the formula is introduced. This shows that bwang assumes that Aznx has understood the work he has presented prior to this step, which Aznx has accepted without further questioning. By referring to the work involved from transferring the sequence $1+2+3+\dots+N$ to $(1+N)*N/2$ as simply applying a “common formula”, bwang downplays the worthiness of instructional work and at the same time assumes the competency of his co-participants of having the relevant knowledge.

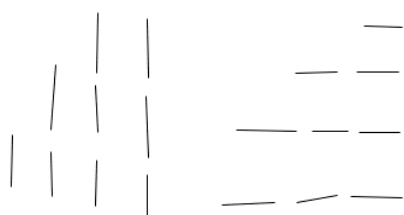


Figure 4.5.2

Bwang’s locating the trouble as lying at the step which he characterizes as involving the application of “a common formula” is received by Aznx as not significant since he explicitly endorses bwang’s assumption on his knowledge on this matter: “Yeah, I know.”. By doing this, Aznx assumes the position of a competent member that bwang is treating him as. In the next post, bwang completes his response

to Aznx’s question by providing a description for rest of the work involved in that step. The description further downgrades the work as insignificant thus explanation would not be necessary – “and just slightly modify it to get this”. He then directs his attention away to the whiteboard and starts performing some drawing actions that seem to be re-organizing the set of horizontal sticks created earlier. This marks that bwang treats the sequence of addressing Aznx’s question as concluded. The sequence of interaction, however, seemingly leaves Aznx’s question unanswered – the trouble source located by the local expert bwang apparently is not the real trouble source. In other words, what Aznx’s question is really “asking” still remains uncovered therefore the trouble is yet to be resolved. If the step to which bwang is attributing the trouble is not problematic for Aznx as he explicitly displays, then the trouble would have to be traced back to the previous steps upon which the most recent one is built, that is, the work bwang has presented earlier that Aznx does not display his trouble for but accepts. Interestingly, in what follows in this episode of interaction, Aznx does not do further work that is recognizable as attempt to reintroduce his trouble, such as asks a different question or makes a self report on what part he has trouble with. Instead, about half a minute later (at 6:36:31), we see a question from Aznx that inquires on the understanding status of the other participant Quicksilver (who he addresses to as Aditya).

Aznx 5/9/06 6:36:31 PM EDT: Aditya, you get this right?
 ██████████
 † Quicksilver 5/9/06 6:37:46 PM EDT: What does the n represent?
 bwang8 5/9/06 6:37:57 PM EDT: the given
 bwang8 5/9/06 6:37:58 PM EDT: N
 Aznx 5/9/06 6:38:02 PM EDT: Yeah.
 Aznx 5/9/06 6:38:05 PM EDT: In the problem.
 ████
 Quicksilver 5/9/06 6:38:37 PM EDT: Oh

Excerpt 4.5.4

assumes the competency of the recipient for being able to understand or “get” it. By not following up his early question (even though the trouble does not seem to have been resolved), Aznx may be abandoning pursuing the understanding work and instead accepting it as the final result. At the beginning of the session, Aznx has asked “So, are we supposed to work together?” (at 6:31:32), which subsequently receives exclaimed positive response from the facilitator Gerry: “Exactly!”. Both this and the fact he tries to engage the group to “collaborate” “even more” in response to bwang’s proposal as we have seen earlier show that Aznx is well aware of the collaborative nature of the work they are here to do. It would not be surprising that here he is assuming the role of a coordinator in the group and checks on the third member to make sure everybody “gets” it, especially considering that the other member has remained silent and not participated in the discussion on the topic so far. As we have seen from the interaction that Aznx and Quicksilver seem to know each other prior to coming to this virtual environment. By assuming Quicksilver “get this”, Aznx’s inquiry could be read as a signal to get help from his friend, who upon “agreeing” to his assumption, would possibly display his understanding such as reformulate what has been presented, which would then help resolving Aznx’s trouble. It is also possible that Aznx is using the inquiry to prompt the third participant to articulate a question regarding the work bwang has presented. This is understandable if we consider that asking a question to disclose one’s troubles of understanding may risk “losing face” and breaching the assumed competency in such a peer group thus is avoided as much as possible, especially when one perceives himself as the only one in the group who does not understand at the moment. As analysts, we do not have access the participants’ inner “mind” and neither are we interested in getting in their head to find out what their “intentions” might be by performing certain actions. What we are interested, is to examine how the action is methodically and procedurally designed and what the interactional consequences it brings to bear. Thus we look at what work the action does in the ongoing interaction by examining how the action is sequentially placed, how it is relevant to prior actions, and what next action it may project. In this case, Aznx’s inquiry sets its implicative as either a) an affirmative answer, which would consequentially hold the interactant accountable for his claimed understanding on the matter, or b) a negative answer, which would make the initiation of trouble as the next relevant action.

The next post does not appear until more than one full minute (74 seconds) later, during which bwang continues with his drawing actions that end up with re-ordering the rows of horizontal sticks and Quicksilver slightly adjusts the position of some of the sticks. The

One basic question that conversationalists ask to set up their analysis is “*why that now?*” (Schegloff & Sacks 1973). What work does Aznx’s question do right here in the sequence? First of all, it is explicitly addressed to Quicksilver (i.e. Aditya) regarding the recipient’s understanding of the matter of concern. It is formulated as a yes/no question with strong preference for an affirmative answer, showing that Aznx

significant delay of answer to the question shows that there may be some interactional trouble in producing it and the answer to come is dis-preferred (Pomerantz, 1984). At 6:37:45, Quicksilver poses a question which calls for a particular answer that is relatively unproblematic for the recipient to produce, with explicit reference to bwan's repair of the typo for "formula". The relevancy of the question to the math expression presented as "the formula" is partly established by the explicit reference to the repair to a prior post, which is explicitly pointing to the math expression. The position of the question in the sequence suggests that it is relevant to Aznx's inquiry, which sets Quicksilver's response as the next relevant move. Quicksilver's question initiates the trouble he has with the presented formula and at the same time serves as a negative answer to Aznx's inquiry that he in fact does not "get this". The question is concerned about what the n represents in the formula. For analysts as well as educators who are mathematically competent, we could recognize that such trouble with " n " in such a math expression probably is a good indicator that the questioner in fact has trouble understanding the formula or what it takes to derive it since it would be rather unreasonable to expect someone to understand the work without even knowing what n is. This reading of Quicksilver's possible trouble with bwan's work is consistent with the fact that Quicksilver is busy getting access to the problem description therefore not likely paying attention while bwan is presenting the steps of his approach and he has remained silent in the rest of the discussion. We also know that it requires certain competency for a questioner to ask an appropriate question regarding his trouble of understanding: one has to know what the trouble is in order to describe it or one needs to ask about the "unknown", which can be challenging. When not able to ask an appropriate question, one may choose to make a self report that discloses the trouble such as "I don't understand", which shifts the burden to the recipient to probe the trouble source and elicits to formulate the question. But this in many cases is being avoided by the participants for something relevant to preserving the peer relationship under which competency, rights, and obligations are allocated among members. One way of initiating the trouble while maintaining member's presumed competency is to ask a question that appears to be competent but not necessarily concerns about the real trouble source. The question serves as an opener to resolving the real trouble. We have also observed participants formulate a rather closed question that demands very little work to produce an answer (compared to a rather "open" question that would require instructional work) as a way of eliciting further elaboration or information, in which case, it is up to the recipients to detect the trouble and offer instructional work of some sort. It also seems that an action, such as a question or request, that calls for instructional work from the local expert, which would involve more work than producing a response to a "closed" question is also dis-preferred. This may also be related to the notion that providing instructions may potentially breach the peer relationship thus is avoided.

The noticeable long time that it takes for Quicksilver to produce this question in response to Aznx's inquiry indicates that it may have taken considerable work for Quicksilver to pull off a rather straightforward question like this in an effort to initiate his trouble of understanding. The question is taken up by both bwan and Aznx as is, who provides an answer in an unproblematic manner: the answer from bwan is brief, posted promptly; it gets endorsement and supplementary information from Aznx without hesitation. How the answer is received by Quicksilver, however, seems to be problematic. His response

appears more than half a minute later that consists of a single “change of state” marker, which is a very weak indicator of achieved understanding, without any further display or demonstration. While indicating his acknowledgement to the answer given to his question, Quicksilver does not display how knowing what n represents helps address his trouble of understanding the formula and the approach used to derive it, which seems to be the real trouble he is having according to our earlier analysis. Bwang, on the other hand, moves on to the next topic – the number of squares – and presents a formula for it about the same time as Quicksilver’s response appears. From the awareness information, we can see that bwang has started composing shortly after he gives the answer to Quicksilver’s question that produces this post. This shows that the answer provided is considered as sufficient and the trouble is resolved in an unproblematic way therefore it is reasonable to move forward to the next topic. Treating Quicksilver’s question as what it appears to be but not as elicitation for more elaboration on the work presented seems to align with the facilitator’s stance, who steps in after both bwang and Aznx respond to the question (and even before Quicksilver’s acknowledgement) and creates a textbox on the whiteboard to post the math expression – “the formula” from bwang’s latest step in the problem solving (Figure X). The formula bwang presents for the number of squares gets endorsement from Quicksilver, who treats it as a final result and accepts it for the group.

† **bwang8** 5/9/06 6:38:38 PM EDT: The number of squares is just $(1+N)*N/2$

☒☒

Quicksilver 5/9/06 6:38:50 PM EDT: We need that as well.

☒

† **Gerry** 5/9/06 6:38:52 PM EDT: I put BWang's formula on the whiteboard

☒☒☒

Aznx 5/9/06 6:39:45 PM EDT: So how do we submit this?

Quicksilver 5/9/06 6:40:26 PM EDT: We are still in the process

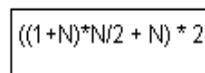
Quicksilver 5/9/06 6:40:38 PM EDT: We are discussing

† **Gerry** 5/9/06 6:40:41 PM EDT: you can complete the table for different N and put that on the wiki

bwang8 5/9/06 6:40:46 PM EDT: OK

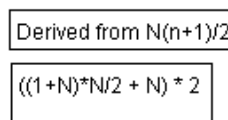
Quicksilver 5/9/06 6:40:56 PM EDT: Do we complete it on the whiteboard?

Excerpt 4.5.5



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

Figure 4.5.3



Derived from $N(n+1)/2$

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



Figure 4.5.4

The facilitator subsequently makes a text post that announces his prior action on the whiteboard: “I put BWang’s formula on the whiteboard”. The meaning of the facilitator’s actions is brought to bear by the participants in the group. Aznx seems to accept it as legitimate and rightful intervention to the group’s problem solving process, who starts creating another text box adjacent to the one created by facilitator immediately following bwang’s post of the formula on the number of squares and includes it in the textbox shortly after. By doing this, Aznx is taking up the practice set by the facilitator’s actions and performing similar actions on another formula. His whiteboard actions are followed by a question inquiring on the logistics of submitting their work, possibly addressed to the facilitator since the facilitator identifies himself as the group’s “VMT guide” and subsequently provides them instructions of the session. This is indeed taken up by the

facilitator as directed to him, who subsequently gives instructions in response to the inquiry, using explicit referencing to Aznx's post. This inquiry however is received by Quicksilver as a proposal to close the discussion on the current topic who then articulates objection to it by indicating it is not yet to be closed. The fact that Quicksilver describes the status of their problem solving as "We are still in the process" and "We are discussing" shows that he does not treat the answer to his earlier question as completing the "process" but rather he considers they are in the middle of the process, revealing that his question may just be an opener to understanding work that he is trying to engage himself and the group to do regarding bwang's proposed approach and formula. However, this "process" of discussion as indicated by himself nevertheless is brought to an end after the facilitator's instructions on submission are given which are taken by the group, including Quicksilver himself, as "instructions" for their next task that they are supposed to do since they move on to taking up a new task suggested in the facilitator's instructions and start working on "complete the table".

Discussion:

If Aznx had trouble understanding what bwang has presented (as soon shows in late of the sequence), Aznx's action in the prior turn successfully moves the interaction organized around the problem solving forward without explicitly introducing the trouble for the group to attend to. Instead, the trouble is considered as potential and put off for later. By engaging bwang in performing further action on the proposed "answer", Aznx may have opportunities to catch up when such "collaboration" is taking place or at least, come to the point that he understands enough what's going to have the competency of posing an appropriate question. Such action also positions them as equal collaborators rather than members with epistemic differentials as an information-seeking question does. When a participant is not competent to ask a question or not willing to do so for various reasons such as face issues, such positioning can engage the other to do certain work and at the same avoid asking a question which would position one as less competent or avoid being treated as competent therefore holding oneself accountable for producing an assessment. Alternatively, when bwang presents his approach of finding the number of sticks, he could have used the same method to explicitly elicit assessment from the members to avoid such situation where an idea does not get picked up because of face issues involved.

It is also worth noticing that the formula for the number of squares is given without reasoning or elaboration on the process of how it is derived. And no question is posed regarding it either. It gets accepted, also endorsed by the action of the moderator who put the formula on the whiteboard, implication of which may mean that it is accepted as final result officially to the team members. Although Quicksilver indicates they are still in the process and discussing, the instruction from the moderator nevertheless serves to intervene the organization of participation. They start performing the task instructed by the moderator and stop the discussion that would otherwise possibly be pursued.

There is also lack of displaying of understanding from recipients when being presented with the strategy of separating the sticks. We have observed that in cases where seemingly more productive interaction organized around math problem solving takes

place, participants routinely display their understanding in the process of doing “understanding work”. It is through display of understanding that participants make learning or understanding an assessable matter. No question is asked by the presenter to check on the recipients’ understanding. Assessment is not provided after the first proposal.

When situation like this occurs, if moderator could detect the potential troubles of understanding that participants are not explicitly articulating and neither does the presenter offer elaboration, then one could step in and intervene such as check whether the participants are following, encourage them to ask question, or get the presenter to explain, etc. This requires our understanding of the phenomena that how participants would or would not bring up their troubles to the group.

4.5.2. Second method: Presenter initiates understanding work

In the analysis we presented in the previous sections, we have looked at how a trouble is initiated by one or multiple participants as recipients. In this section, we examine another way of how the understanding work related to a potential trouble gets initiated, which is the presenter of the idea or proposal elicits report of understanding status from the recipients. We show analysis of an episode to show how the trouble is initiated and how it is attended in the group.

137 5/11/06 8:04:42 PM EDT: So the blue is n^2 and there are 4 more squares outside for each...

 † qwertyuiop 5/11/06 8:05:12 PM EDT: that's number of squares?
 137 5/11/06 8:05:24 PM EDT: IT should be...
 137 5/11/06 8:05:26 PM EDT: shoot.
 ■
 † qwertyuiop 5/11/06 8:06:23 PM EDT: or number of sides?
 137 5/11/06 8:06:37 PM EDT: I screwed up somewhere...
 † qwertyuiop 5/11/06 8:06:50 PM EDT: what are you trying to find?
 137 5/11/06 8:07:19 PM EDT: The number of squares.

Excerpt 4.5.6

question that problematizes his approach (i.e. “so +4 is just for a side length of 3?”), 137 comes to realize that there is some problem and articulates it to the group: “I screwed up somewhere...”. The sequence of analysis here starts with how Jason and qwer respond to 137’s admitting of the problem of the current approach by proposing an alternative respectively.

For this session, the team has come up with their own problem to work on that they have defined as “diamonds”, following which 137 proposes a formula for the number of squares using “side length”, some artifact he has created himself. The recipients hereafter get 137 to explain his method during which they come to a shared understanding of the “side length”. Upon producing the account for how the formula is derived in response to a

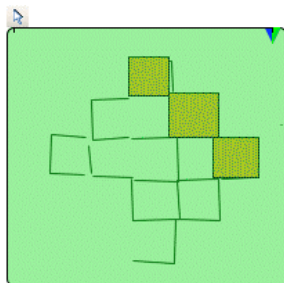


Figure 4.5.5

Jason 5/11/06 8:07:36 PM EDT: actually... could this be figured out by using some geometric series

← **Jason** 5/11/06 8:08:18 PM EDT: the fact that, when the squares are arranged in a diamond shape result in 1+3+5+3+1 total squares in the diagram to the left, remind me of pascal's triangle

Jason 5/11/06 8:08:35 PM EDT: just a thought... not sure if it'll work

† **qwertyuiop** 5/11/06 8:08:35 PM EDT: using your previous method: $SideLength^2 + (SideLength-1)^2$

Excerpt 4.5.7

At the first line, Jason presents his alternative approach that is formulated in a rather preliminary form – “some geometric series”, on which he elaborates in the following post and offers the series in particular along with the reasoning. The elaboration is completed with explicit reference to the “diamond” shape on the whiteboard that they have created earlier. Jason’s proposal of idea does not get response within the next 17 seconds or so, when he promptly adds some comment that backs up his stance by downplaying what he has presented to “just a thought” followed by articulation of his own uncertainty. From the awareness information displayed in the system, we can see that qwer has been engaged in typing activity shortly after Jason starts composing his post in which he presents his approach, and since until he posts at the same time with Jason’s third post of the three in a row (at 8:08:35). This shows that qwer’s attention might have been diverted to composing his own post therefore not have been oriented to Jason’s posts. Qwer’s post appears to be in some form of a math formula, using explicit reference to point to 137’s post “The number of squares” a few lines back, a response from 137 clarifying what his earlier explanation is concerned about. How this post is designed to be an alternative proposal to 137’s is achieved by the connection established from this explicit reference as well as reference to some shared artifact:

- 1) the completion of the proposal is done by making use of 137’s post being pointed to so that the math formula presented in the current post is about “the number of squares” therefore an alternative to 137’s;
- 2) it designates the author of the post being pointed to, i.e. 137, as the referent of the deictic reference in the current post – “your previous method” to explicitly refer to some shared experiences that the group, especially 137, is supposed to know;
- 3) the explicit reference to “SideLength” being described as a “method” here points to some artifact that is supposed to bear some shared meaning for the group, which in this case, an artifact that the group has constructed together in their prior interactions which we have looked at in some separate analysis (see analysis of the sequence on “side length” in Section 4.1.2 case study 1).

Up to this point, there are two separate ideas proposed as alternative approaches to the current one that has been problematized by its own presenter and one of them has been backed down and downplayed as “just a thought” and may not work. Proposals like these call for uptake or response of some sort from the recipients as the next relevant action, among which one common form is making an assessment. In the following analysis, we show how qwer as someone who presents an idea for the group to consider, employs

various interactional methods to get his idea “noticed” by the recipients, or in other words, to engage others to doing “understanding work”. As a result, the trouble the two participants initially have on understanding the proposed idea finally gets introduced, more elaborated explanation is produced in response to the articulated trouble, and shared understanding gets constructed.

† **qwertyuiop** 5/11/06 8:08:51 PM EDT: does that work?
 † **qwertyuiop** 5/11/06 8:10:06 PM EDT: the part in front of the plus is the large, rotatewd 45 square and the part after it is the smaller, not rotated squared
qwertyuiop 5/11/06 8:10:59 PM EDT: um... hello?
137 5/11/06 8:11:03 PM EDT: Hi.
 † **Jason** 5/11/06 8:11:17 PM EDT: well, looking at the center diagram with the orange boxed

Excerpt 4.5.8

The formulation of proposal such as qwer’s here, however, does not strongly constrain its uptake, that is to say, lack of response in the next action would not be “noticeably absent” (Schegloff, 1968; Sacks, 1992). One remedy for such formulation to get the proposal noticed and acted upon would be to explicitly elicit a response such as ask a question that imposes an answer, which is what qwer does in this case. Upon receiving no reaction to his proposed idea, qwer poses a question shortly after (in 16 seconds) pointing to his prior post of the formula that explicitly elicits an answer. Formulated in a yes/no question, it calls for the work of checking the formula in order to produce the answer. About 20 seconds have elapsed but still no sign of either of the two participants responding to the question and there is even no observable activity happening in the system according to the awareness information. Qwer then starts composing some message, which takes almost a full minute and finally comes out as some elaboration of the proposed formula, with the use of explicit reference (pointing the current post to the one with the formula) to make such connection. The elaboration seems to be organized to explain how the two parts of the formula are respectively corresponding to some visual representation of the shape. Referencing terms include “the large” square and “the smaller” are used but their referents do not seem to be apparent at this point, certainly from analysts’ perspective. By providing elaboration (or explanation) of the proposed formula, qwer seems to treat the recipients failing to respond to his question that elicits check work as noticeably significant and problematic. More particularly, the action suggests that qwer attributes the source of such trouble to recipients’ failing to understand the formula he has presented and the action is performed to address the trouble. The explanation, which is expected to help recipients understand the formula, however does not seem to do the job at all for that 43 seconds have passed but still there is no sign of recipients reacting to what has been offered so far. The next post from qwer is designed to bring up to the attention of the group this situation that a response is “noticeably absent”: “um... hello?” (at 8:10:59). It uses greeting, a form that is familiar to all of us in daily life, which usually comes in pairs as exchange of greetings. So “hello” here serves as a *first-pair part* of an *adjacency pair* (Schegloff, Jefferson & Sacks, 1977) – greetings – plus a question mark that strongly implicates the second-pair part (greeting which in this case would be associated with the recipient’s attention given to what has been offered earlier), meaning that the lack of it

would be noticeably problematic and result in interactional trouble. Up till now, qwer has employed three interactional methods to elicit response from the recipients regarding an idea he puts forward as an alternative proposal when one method fails to do such work.

† **qwertyuiop** 5/11/06 8:11:18 PM EDT: but does that work?
Jason 5/11/06 8:11:20 PM EDT: boxes
Jason 5/11/06 8:11:24 PM EDT: you'd be 1 off
Jason 5/11/06 8:11:41 PM EDT: nvm, my arithmetic skills faltered ther
Jason 5/11/06 8:11:42 PM EDT: e
 ☐☐
Jason 5/11/06 8:11:59 PM EDT: there
qwertyuiop 5/11/06 8:12:03 PM EDT: checking for SideLenght=3...
 † **Jason** 5/11/06 8:12:35 PM EDT: works
 † **qwertyuiop** 5/11/06 8:12:36 PM EDT: yes, it works
 Excerpt 4.5.9

Qwer's persistency in eliciting response to his proposed idea finally gets the two participants' attention: 137 returns greeting whereas Jason reports results of some checking work he has performed, formulated as dis-preferred response with "well" prefacing, which he immediately backs down as incorrect. Upon receiving returned greeting from 137 that is taken as properly allocated attention, qwer reiterates his call for checking work be performed on his formula (at 8:11:18), imposing strong constraints on what should happen next – an answer – since the possibility that attention is not being allocated to the current actions is eliminated. Qwer then initiates the checking work himself and reports to the group that he is engaged in "checking for SideLenght=3". The report is appended with ellipses that indicate the work is ongoing and project that result may be reported in coming actions. This engages Jason to perform the checking work as well for that he reports that "it works", which gets confirmed by qwer. Jason subsequently moves on to propose closing of the topic by accepting it as the formula for the group. By doing this, Jason treats the checking work as done. His action also shows that closing of the discussion around the proposed formula is considered to be grounded on the fact "it works" rather than on the understanding "how it works".

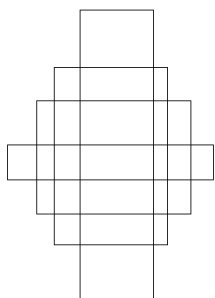


Figure 4.5.6

Jason 5/11/06 8:12:52 PM EDT: cool, so should we call this a formula
 † **137** 5/11/06 8:12:57 PM EDT: I don't get why though...
 † **Jason** 5/11/06 8:13:29 PM EDT: i dont either
 ☐☐☐☐

Excerpt 4.5.10

It is at this point that 137, who has remained silent most of the time during the period of time for this sequence (except returns greeting to qwer's call), articulates his trouble of

understanding in a self report. The referent used in the report is pointed to by the explicit reference back to qwer's post "yes, it works". 137's report of trouble here serves to object the proposal of closing by indicating that some trouble of understanding he has will need to be attended to before they as a group can move on to "call this a formula". What is rather more interesting is that this report disclosing trouble of understanding is echoed by Jason around half a minute later, the very participant who was initiating the closing of the discussion on the current topic in the prior action. This second report escalates the trouble to a bigger one that will need to be attended before other action can happen since the trouble shared between two participants among the three halts the progressivity of the ongoing interaction, which can be restored only when the trouble is resolved. Following his report, 137 performs some drawing actions on the whiteboard that produce a shape of "diamond", which appears to be at the fourth stage of growth, the next stage to the one they have created, which has been used as referential resources for illustrating the "side length" earlier and explaining qwer's current formula. By performing the actions, 137 makes the diagram relevant to how addressing the trouble should be approached.

† **qwertyuiop** 5/11/06 8:14:10 PM EDT: I used your previous method: take the (orange) side; that² gives part of the shape...

† **qwertyuiop** 5/11/06 8:15:03 PM EDT: the rest happens to be a square with a side length of one less, therefore th "(SideLength-1)²"

qwertyuiop 5/11/06 8:15:10 PM EDT: does that make sense?

Jason 5/11/06 8:15:42 PM EDT: i get it!

Jason 5/11/06 8:15:43 PM EDT: clever :)

qwertyuiop 5/11/06 8:15:48 PM EDT: 137?

137 5/11/06 8:15:56 PM EDT: Now I do.

Jason 5/11/06 8:16:17 PM EDT: ok

Jason 5/11/06 8:16:49 PM EDT: so in the little time we have left, should we discuss the second part of this problem -- what if instead of squares you used other polygons

Excerpt 4.5.11

In response to 137's report of trouble, qwer produces a seemingly more elaborated explanation that is delivered in two consecutive posts. The time it takes to produce the two posts is fairly long: qwer starts typing at 8:13:02, which comes out to be the first post more than a full minute later at 8:14:10, and the second post takes nearly a minute as well to compose. During the second full minute or so there is no activity by the two participants, which is probably an indicator that they are both attending to qwer's actions. Upon completing his explanation, qwer again poses a question to explicitly elicit a report of the recipients' status of achieved understanding. In response, Jason makes a positive report "I get it" with an exclamation mark possibly showing emphasis on the contrast of two states of understanding. This is followed by a positive assessment to the approach. Both serve as relatively strong display of achieved understanding as a result of the explanation produced. Upon the elicitation of report specifically addressed to 137 as the recipient, 137 also makes a positive report: "Now I do." which makes contrast to previous state of understanding. In the subsequent move, Jason brings the current topic to closing by orienting the group to move on to a new task. The trouble seems to be considered as resolved by all participants and sequence closed.

Discussion:

The trouble caused by the ambiguity of the referents is resolved by using the shared referential resources – the “orange” side. The second explanation produced replaces “SideLength” from the first one with “the (orange) side”, orienting the recipients to the visual representation. Explicit reference to “your previous method” is also made in both of the explanations, treating the “method” as a shared knowledge artifact in the group with attribution of authorship of the method. Qwer actively attempts to engage others by being persistent on eliciting reports of their understanding status. If qwer has not been persistent on engaging others, the trouble of understanding perhaps would never been disclosed or brought up by 137 and of course would not by Jason, who makes attempt to closing the topic by orienting the group to move on. Jason only articulates his trouble of understanding after 137’s self report by echoing to the report that he shares the same trouble.

4.6. Lack of questioning (or understanding work)

In this section we are set to explore the phenomenon of lack of “questioning” where ideas or proposals are put forward for the group members to consider but simply get “dis-attended”. Either the participant who offers the idea does not seem to provide elaboration or similar actions in engaging its recipients to doing “understanding work”, or the recipients do not “ask a question” to initiate “understanding work”, leaving ideas getting lost and us as analysts and educators wonder how this happens.

4.6.1. Initiating a separate thread

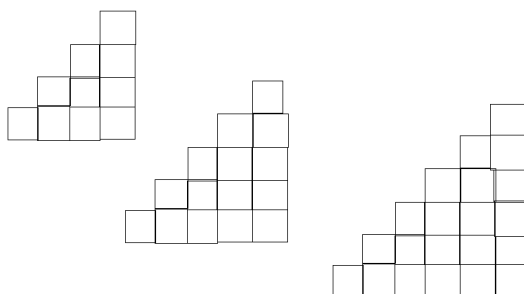


Figure 4.6.1

■■■■■■■
Jason 5/9/06 6:26:21 PM EDT: so do we see how the number of sticks grows in a sequence?
dauidcyl 5/9/06 6:26:25 PM EDT: ok i've drawn n=4,5,6
Jason 5/9/06 6:26:29 PM EDT: $4(+6) = 10$
Jason 5/9/06 6:26:36 PM EDT: $10(+8) = 18$
■■■
Jason 5/9/06 6:26:48 PM EDT: i'm guessing $18(+10) = 28$ for the next one, according to this pattern

Excerpt 4.6.1

This sequence of interaction takes place at near the very beginning of the first session of this group – Team C. At the first line of this excerpt, Jason tries to orient the group to a particular task presented in the problem description provided to them by posing a question which organizes the group as a collectivity and serves to elicit proposals of ideas. This post, however, appears about the same time as the last action of a series drawing actions that dauidcyl has engaged in doing starting at the beginning of the session. From the awareness information made available when reproducing the sequence of interactions

in the VMT replayer software, we see that davidcyl starts typing right after his last drawing action by which he composes a post that appears only 4 seconds after Jason's, in which he summarizes his prior actions. The post serves to mark the completion of his drawing actions and at the same time annotate them as "n=4, 5, 6". The relevance between the text post and the drawing actions is established by the sequential order of them as well as the use of "ok" as a marker for completion of actions and the use of past tense. By announcing the completion of constructing figures for stage n=4, 5, 6 that seem to be corresponding to the three individual figures on the whiteboard, davidcyl orients other participants to what has been constructed on the whiteboard – invites others to inspect it – and indicates his readiness to move on to the next step. This opens up the space for the next reasonable action therefore provides opportunity for others to contribute.

Davidcyl's invitation for others to inspect the figures he has created however does not get taken up in the immediately following posts, where Jason follows up his own initiation of the task of figuring out "how the number of sticks grows in a sequence" and offers his observations on the pattern of the growth. Jason's observations are made in three consecutive posts. The last one is formulated as a speculation of the number for the next stage, which Jason claims to be made based on the observed "pattern". By offering his observations and "guess" on how the numbers (of sticks) grow over stages, Jason presents his approach for "seeing" how the number of sticks grows. This approach seems to be oriented to observing how the "numbers" change then generalizing based on the pattern of change. Making the reasoning process available invites others to examine and assess. This invitation made through the form of statement however is not particularly explicit and does not compellingly make a response the next action (Schegloff & Sacks, 1973; Schegloff, 1995).

There is more than 40 seconds elapse after Jason's third consecutive post before the next action in the sequence, during which Jason does not elicit reaction from the recipients or offer more elaboration. In the next post, davidcyl offers an observation on the generalized pattern of the growth for the number of *squares*. This is immediately followed by a continuation of the observation in which a math expression for "the number of squares in the nth pattern" is presented. These postings show that it is quite obvious that davidcyl's offering is oriented towards the number of squares, instead of the number of sticks as proposed by Jason at the beginning as a task for the group. By *initiating a separate thread* of discussion, davidcyl "dis-attends" Jason's proposal of task and his idea of approaching it presented in the subsequent posts. It should be noticed that the feature of displaying awareness information of whiteboard activities in the chat area (as shown as little squares in the excerpt taken from reproduced session in the replayer) was not available at the time of the interaction – it was only introduced to the system as a new feature in a later session of the group. This means that the awareness information available for us as analysts now when we reconstruct the session for inspection was not available to the participants at the time. The lack of awareness information on whiteboard activities can be consequential for the interactions taking place within the environment and in this case does appear to be. As the awareness information shows, davidcyl has been engaged in drawing actions on the whiteboard from the beginning of the session.

There is overlap between Jason's composing action that produces the post in which he invites the group to work on the task of finding "how the number of sticks grows in a sequence" and davidcyl's post in which he summarizes his drawing actions and invites others to inspect the figures created. The timing of the sequence shows that their attention appears to be allocated in the two different spaces – the whiteboard and the chat area. Although their posts appear to be intertwined sequentially, the two participants are not attending to each other's contributions. Rather, they are oriented to their own separate thread of topic: one is concerned about the number of sticks while the other the number of squares.

davidcyl 5/9/06 6:27:32 PM EDT: the nth pattern has n more squares than the (n-1)th pattern

davidcyl 5/9/06 6:27:55 PM EDT: basically it's $1+2+\dots+(n-1)+n$ for the number of squares in the nth pattern

137 5/9/06 6:28:16 PM EDT: so $n(n+1)/2$

davidcyl 5/9/06 6:28:24 PM EDT: and we can use the gaussian sum to determine the sum: $n(1+n)/2$

davidcyl 5/9/06 6:28:36 PM EDT: 137 got it

Excerpt 4.6.2

Davidcyl's contribution is taken up by the third participant present in the session with handle name 137 (who has remained silent from the beginning of this sequence) in the immediately following post, in which a math expression is presented. Prefaced with "so", the post indicates what to come is derived from some previous actions, which, presumably are the immediately preceding actions. The fact that davidcyl's proposal is elected to be taken up marks that the chance for Jason's idea to get taken up has elapsed at this point, after the silence following the last post of the idea and the initiation of a separate thread, unless extra effort of some sort is made to reintroduce the idea or to re-orient the group to it.

How Jason's contributions do not make the next action explicit as implicative, although it can be read as inviting assessment for what's been presented or alternative observation from others. The same features apply to the design of davidcyl's offering, except that it is formulated and presented in a relatively more assertive form and appears to be in a format of a more final result. The expression of the sequence of numbers also seems to invite actions to be performed on operating on it, which is what 137 does in the next position. Davidcyl's approach to finding the pattern of growth for the number of squares makes use the visual representation of the three stages of figures, as he is trying to orient the group to. Jason's however is oriented to the change of numbers presented in the problem description – as presented in the innovative way of using parenthesis in the math equations to show such change. The reading of Jason's equations would involve referring back to the document of the problem description, which is not readily available in the environment where interaction is taking place, therefore possibly adds to the effort for others to make sense of the approach. If we take a look at the problem description given to the participants, it is also noticeable that the first task listed for the current session (i.e. Session I) is explicitly written as "*Draw the pattern for $N=4$, $N=5$, and $N=6$ in the whiteboard. Discuss as a group: How does the graphic pattern grow?*". Davidcyl's actions are obviously aligned with the current task defined for the group whereas Jason's

proposal of task and the approach he presents subsequently are not. This may also have contributed to the group's dis-attending Jason's contributions.

In summary, from our analysis, we show that how implicative of the design of posts, their sequential order and timing in the sequence, institutional setting (i.e. what may be considered as an appropriate task at the time), as well as the affordances of the system features (that allow problematic attention allocation of participants), all interplay together and possibly contribute to the dis-attending of Jason's idea.

4.6.2. Making a dismissive comment along with an alternative proposal

In the subsequent post, davidcyl produces a continuation of his observation on the pattern. The post as a continuation of prior actions is indicated by the use of "and" as a preface. The action reported is characterized as finding *the sum* using a method called "the gaussian sum". Considering the connection between the post and the prior one from davidcyl, it is rather unambiguous that "the sum" is referring to the sum of the sequence of numbers in the prior post. The math expression presented as "the sum" appears to be exactly the same as 137 has presented. This alignment is recognized by the idea presenter davidcyl who subsequently provides an explicit endorsement to 137's offering: "137 got it" (at 6:28:36).

In talk-in-interaction, interactants routinely display their understandings (Sacks, Schegloff, & Jefferson, 1974) of the prior actions to each other. The "architecture of intersubjectivity" (Heritage, 1984), a systematic byproduct of turn organization, provides for the recurrence and stability of understandings.

It obliges its participants to display to each other, in a turn's talk, their understanding of other turn's talk. More generally, a turn's talk will be heard as directed to a prior turn's talk, unless special techniques are used to locate some other talk to which it is directed. (Sacks et al., 1974, p. 728)

Among the methods participants use for displaying understandings, a commonly used one is to perform a next reasonable action that fits in the progression of the ongoing interaction. By performing summing the sequence of numbers presented by davidcyl in proposing his approach to the problem, 137 demonstrates his understanding of davidcyl's approach and at the same time provides endorsement to it. This displayed understanding is subsequently ratified by davidcyl who makes a positive assessment, of which the referent seems ambiguous – it could be read as an assessment of the correctness of the math expression 137 produces or an assessment of 137's "understanding" of what he is trying to present. During this drag of sequence of interaction, there have been chances where the other participant Jason could have participated. The lack of action from Jason is treated nevertheless neither as interactionally significant nor problematic for that in the next action 137 moves on and initiates a new topic which at the same time serves to conclude the current one.

137 5/9/06 6:28:43 PM EDT: and $2(1+2+3\dots n-1)$ overlaps
 137 5/9/06 6:29:05 PM EDT: so $n(n+1)/2 - n(n-1)/2$?
 davidcyl 5/9/06 6:29:31 PM EDT: well to find the number of sticks:
 davidcyl 5/9/06 6:29:39 PM EDT: let's look on the board
 ■■■

Excerpt 4.6.3

The next action by 137 involves two consecutive posts. Prefaced with “and”, the first post is designed to be connected with prior actions while is oriented to a distinctively different topic than the previous. The “so” preface in the second post indicates what follows, which appears to be a formula of some sort is derived from the first post. The second post is formulated as a question by appending a question mark to the end, eliciting a response from the recipients, in particular, a positive assessment as preferred, to the presented math expression. This is taken up by davidcyl as an offer of an approach to finding the pattern of the number of sticks, who makes a *dismissive comment* in response to the elicitation for assessment. Davidcyl’s response does not appear until almost half a minute later, a rather significant delay in chat which in this case marks the response to come as dis-preferred (Pomerantz 1978, 1984; Sacks 1987). The fact that the response starts with “well” also contributes to marking it as dis-preferred (citation). Davidcyl orients the group to “the board” by proposing an action for the group as a collectivity – “let’s look on the board”. This projects some actions on the whiteboard to come, which are projected to be organized as producing an alternative to what has been presented, as set up as a relevant next action. The completion of the alternative proposal is accomplished after an insertion sequence initiated by a question from Jason. In fact, what follows immediately are a series of drawing actions performed on the whiteboard by davidcyl, marking the horizontal lines on the first figure (at the upper left corner of the whiteboard area) with scribbles starting from the top (Figure 4.6.2).

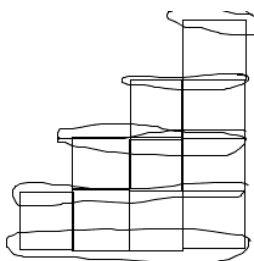


Figure 4.6.2

Although the prior action by 137 makes an assessment as the relevant next action, the response from davidcyl however dismisses 137’s proposal in a skillful and artful way, without being “noticeably or non-trivially absent” (Sacks, 1972b; Schegloff, 1972). One question for us as analysts to ask is how this is achieved in the interaction. The preface “well” serves to acknowledge the prior action but at the same time treat it as inappropriate – it could be that the occurrence of it is considered as out of place in the sequence or the proposal itself as something problematic, e.g. incorrect. Assessment to the proposal that is being called for would require adequate understanding of what has been presented and subsequently, a negative assessment would put producing an account for the assessment as the next relevant action. However, in this case, understanding work

does not happen. What has been presented by 137 that is recognized as an approach to finding the number of sticks – the next topic given for the group – is simply dismissed.

If we take a closer examination of 137's action, we come to see that the "dis-attending" may have to do with the design of his proposal, which seems to be rather problematic. First of all, there is no setup for the new task being introduced. It assumes that its recipients know what the proposal is about. Although davidcyl's response acknowledges the task 137's proposal is dealing with, the proposal itself is not complete therefore seems out of place without giving proper orientation to its recipients. Secondly, a term "overlaps" that is not recognizable as a predefined math term is introduced in the proposal as an approach from which the subsequent formula is derived. Again, it assumes the competency of the recipients to know this term, although the referent appears rather ambiguous. There is no further elaboration on the approach or reasoning steps before the formula as a final result is presented. Some manipulating steps for getting the sum of the "overlaps" are also omitted. This shifts the burden of "understanding" the proposal to the recipients, which, when perceived as too much work because of the lack of clarity in the presentation, may naturally result in the dismissive action. Thirdly, the formula itself is problematic. As a formula for the number of sticks, it is however presented as subtraction of "overlaps", which is incorrect from analysts' point of view therefore could be source of trouble for the recipients, from the number of squares that they have just worked out. This incongruence could also have added to the problematic nature of the proposal. From the recipient's side, by dismissing what's been presented and orienting the group to an alternative approach (that we will see in a bit), davidcyl positions himself as the local expert, an authoritative figure, who could make judgment that the offering is not worth pursuing and has the alternative approach ready to present to the group.

While davidcyl is engaged in some drawing activities following his post that orients others' attention to the "board", the third participant Jason, who has remained silent since davidcyl starts the new thread, steps in with a yes/no question with two candidate answers (at 6:29:54). Such question is designed to elicit an answer that is one of the two candidates. Posing a question like what Jason does shows certain epistemic stance that the questioner holds (Koshik, 2005). In this case, the question displays that the questioner is able to recognize that "it" can be described as one of the two "definitions" and choosing one "definition" is something relevant that the group needs to consider. The question also projects producing an account for the selected answer as a relevant action. Davidcyl, who again assumes the position of a local expert, rejects one of the candidate answers and offers an account for choosing the other.

Jason 5/9/06 6:29:54 PM EDT: should we use a recursive or explicit definition for it
 **
 † **davidcyl** 5/9/06 6:30:20 PM EDT: i don't think we need recursion
davidcyl 5/9/06 6:30:33 PM EDT: it's simpler to express it as $1+2+...+n$
Jason 5/9/06 6:30:50 PM EDT: would that be the number of sticks>

Excerpt 4.6.4

A more interesting question for us as analysts to ask is what work Jason's question does here, "why that now?" (Schegloff & Sacks, 1973). What "it" may be referring to in Jason's question is not identified, although it is taken up by davidcyl as the math expression for the number of squares that has been discussed earlier. However, by the rule of proximity in conversations (Sacks, Schegloff & Jefferson, 1974), Jason's question is more likely to be relevant to the immediately preceding action – 137's proposal of the formula and his approach. Jason's follow up question (at 6:30:50) also indicates that he does not recognize the math expression davidcyl treats as relevant and he is oriented to the number of sticks, rather. The question is not a simple information question as it is treated by davidcyl but perhaps rather a challenge to what has been presented in that it invites consideration on whether 137's formula is the proper "definition" that the group "should use". This is a way to decide whether a proposed idea is "legitimate" for the group to pursue without unpacking other details such as the underlying reasoning or the manipulation of the math expression. It therefore offers a possibility for the idea to get dismissed without providing assessment that is being called for. Another thing Jason's question does here seems to do with his proposal for figuring out how the number of sticks grows at the beginning of the sequence, which is concerned about how the sticks grow in relation to the previous stage – a "recursive" approach as he characterizes in his candidate answers. His approach is ignored by the group when a parallel new thread is introduced by davidcyl and gets taken up by 137. Posing the question here could be an effort Jason is making to re-orient the group to his abandoned approach, since rejecting the current "explicit definition" would entail introducing a "recursive" one.

davidcyl 5/9/06 6:30:51 PM EDT: anyway, when $n=4$, there's $1+2+3+4+4$ horizontal sticks

davidcyl 5/9/06 6:31:03 PM EDT: and $1+2+3+4+4$ vertical sticks

Jason 5/9/06 6:31:06 PM EDT: let's see

Jason 5/9/06 6:31:08 PM EDT: when $n=2$

137 5/9/06 6:31:21 PM EDT: then we have 5.

davidcyl 5/9/06 6:31:23 PM EDT: no, squares

davidcyl 5/9/06 6:31:37 PM EDT: sorry i wasn't clear

137 5/9/06 6:31:41 PM EDT: $5*2=10$.

137 5/9/06 6:31:45 PM EDT: ?

Excerpt 4.6.5

In the next post that appears about the same time as Jason's follow up question for clarification, davidcyl goes on to present his approach to finding the number of sticks as alternative to 137's that is clearly referring to the scribbles he has created on the diagram as illustrations. By making the post with a "anyway," prefacing, davidcyl treats the question-response sequence initiated by Jason as complete and also marks it as an "insertion sequence" to the ongoing sequence organized around the current topic. The prefacing thus serves to re-orient the group back to the topic that has been deviated from and continue the interrupted actions. The approach presented by davidcyl is received by Jason promptly who initiates some checking work on it, which is subsequently performed by 137. The checking work executed by 137 is presented in two steps that are corresponding to the two steps of counting the horizontal and vertical sticks respectively as davidcyl's approach offers. By doing this, 137 demonstrates his understanding of the approach. While 137 is presenting his checking result, davidcyl produces a response to

Jason's clarification question. Its position in the sequential order apparently has caused confusion among the two recipients due to the lack of clear reference and the skewed "turn-taking" mechanism in chat (Garcia & Jacobs, 1999) (need some discussion in a separate chapter). The interaction that follows in the sequence appears to be rather muddled where participants display their confusions or misunderstandings and together produce the disorderliness of their interaction. 137 shows his trouble understanding how davidcyl's response and apology fit there, or in other words, trouble caused by "problematic sequential implicativeness" (Schegloff, 1987a) by producing a question mark as a separate post in the subsequent line. This however, is taken by davidcyl as a request for explanation of his approach for he produces a reformulation (at 6:32:21) of what has been presented in the two lines (at 6:30:51 and the next line). This reformulation is directed to 137 as an explanation by starting the post with "137:" to designate 137 as its recipient. This is treated by 137 as a negative assessment to his proposal at 6:32:20 and davidcyl is being positioned as the authoritative figure in the group.

Jason 5/9/06 6:31:54 PM EDT: ooh
Jason 5/9/06 6:32:02 PM EDT: well could you just use like
137 5/9/06 6:32:20 PM EDT: $n(n+2)$?
davidcyl 5/9/06 6:32:21 PM EDT: 137: i'm separating the sticks into vertical and horizontal sticks
137 5/9/06 6:32:25 PM EDT: oops.
Jason 5/9/06 6:32:28 PM EDT: # sticks = $N*(3+N)$
davidcyl 5/9/06 6:32:30 PM EDT: wait what are you working on?
Jason 5/9/06 6:32:32 PM EDT: wait lemme check
davidcyl 5/9/06 6:32:35 PM EDT: (to 137)
137 5/9/06 6:32:46 PM EDT: Great. Confused.
Jason 5/9/06 6:33:03 PM EDT: 137 are you talking about # sticks or squares
137 5/9/06 6:33:09 PM EDT: Sticks.
Jason 5/9/06 6:33:18 PM EDT: OK

Excerpt 4.6.6

How davidcyl's two consecutive posts are received by Jason also seems to be problematic. Jason produces "ooh" in a separate post, which does not fit in the progression of the checking work he has initiated therefore is rather produced in response to davidcyl. Following this "change of state" token (Heritage, 1998) that displays some achieved understanding (or possibly rather "misunderstanding" in this case) to davidcyl's action, Jason offers a formula for the number of sticks in the format of a final result. This action halts the ongoing checking work for the approach proposed by davidcyl and serves to abandon pursuing the approach. One possible understanding of the work that Jason's posts do here is that they are treating davidcyl's post that appears sequentially after his presentation of the approach as self-repair (Schegloff, Jefferson, & Sacks, 1977) and thus the apology offered as a depreciative self assessment of what has just been offered. This is aligned with the formulation with Jason's proposal, prefaced with "well" that marks a dis-preferred response (Pomerantz, 1984). This serves to conclude the prior topic that deals with davidcyl's proposed approach and introduce his own as an alternative therefore can be potentially face threatening (Goffman, 1967). The action is also an agreement to davidcyl's depreciative self assessment (which is read as such) therefore

dis-preferred (Pomerantz, 1984). Putting Jason's actions together, the "ooh" prefacing and "well" are used to convey what follows is dismissive of the matter raised by davidcyl, i.e. his approach being problematic (as read by Jason as such) and shift the topic to his new proposal (Schegloff and Lerner, 2009 **beginning to respond**; Heritage 1998) in a mitigated way. The formula is proposed in a form of yes/no question that is designed to make a suggestion to avoid dis-affiliation (**citation**). It is rather interesting that the pronoun "you" rather "we" is used here, which seems to do the work of making a suggestion with stronger epistemic stance other than offering an idea to elicit assessment. The formula appears to be a form of a final result. No further elaboration on the formula or any steps for its underlying reasoning are presented. The use of "just" also seems to suggest what's being presented is rather straightforward and unproblematic, positioning its recipients as competent to understand it.

Before Jason's formula is presented in a separate post after the setup at 6:32:02, in its immediately following line 18 seconds later, 137 produces a similar formula that ends with a question mark, seemingly eliciting assessment from the group: " $n(n+2)$?". This math expression on its own as a simple post without any elaboration or any setup in the sequence produces "problematic sequential implcativeness" (Schegloff, 1987a), causing troubles for its recipients that are displayed later. At 6:32:30, davidcyl poses a question for clarification, problematizing 137's action. The question's recipient is selected as 137, as subsequently repaired (at 6:32:35). 137's earlier post, which consists of a single question mark, is treated by davidcyl as display of trouble and he offers an explanation. This results in confusion for 137, who seems to take it as a criticism or dismissive comment to his proposal of formula. In both cases, "a turn produced to do one action is taken by its recipient to be doing a different action" (Schegloff, 1987a) and disorderliness is consequentially produced. Davidcyl's subsequent clarification among the muddled sequence where Jason is trying to dismiss davidcyl's approach and present his formula exacerbates the disorderliness that 137 articulates his confusions and frustrations in an ironic tone: "Great. Confused.". Jason intervenes the situation by reformulating the clarification question which has failed to elicit the answer. Explicitly addressed to 137, the reformulated question is designed as a yes/no question with two candidate answers, displaying his understanding that 137's formula is a proposal on either the number of sticks or squares. Although the trouble the two members have regarding 137's formula seems to be resolved by 137's answer to Jason's question, this proposal is nevertheless abandoned by the group, for that following this insertion sequence of doing clarification, davidcyl presents a formula as an alternative, formulated as "i would think it's". By doing this, davidcyl again dismisses the two current proposals from Jason and 137 respectively. He subsequently provides the reasoning for how the formula is derived drawing back on his approach of "separating the sticks" and carrying out the next step that appears to be adding up the horizontal and vertical sticks (at 6:33:57).

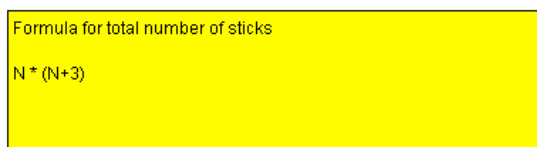
dauidcyl 5/9/06 6:33:21 PM EDT: i would think it's $2(n(1+n)/2) + n + n$
Jason 5/9/06 6:33:23 PM EDT: well i think my formula works
Jason 5/9/06 6:33:33 PM EDT: provided that you have a value for N
dauidcyl 5/9/06 6:33:57 PM EDT: because it's basically $(1 + \dots + n + n) + (1 + \dots + n + n)$
dauidcyl 5/9/06 6:34:12 PM EDT: checking

Excerpt 4.6.7

4.6.3. Discussion

This sequence is particularly interesting for us as educators and analysts in that promising proposals (with underlying educationally interesting ideas or approaches) to solving the problem are presented but get dismissed. One question that we wonder is that how this happens and how participants organize their participation in presenting and attending to ideas or dis-attending them. Understanding this phenomenon seems to be two folds. From a presenter's side, the ways the proposals are made are rather problematic. As our analysis shows, 137's formula is presented with no setup and the "proposal" itself does not take the form of a complete "proposal" – both recipients have trouble understanding what 137 is "working on". There is also no elaboration or reasoning provided. Also, the fact that 137 does not initiate understanding work, such as ask a question to prompt recipients to display their understanding when there is a lack of display of understanding, also allows the "dis-attending" happen. Although the trouble is subsequently resolved, the "proposal" nevertheless fails to stand out as a firm well-presented one to get the attention from the group. Jason's formula, although is presented as a complete proposal, similarly lacks elaboration or offering of reasoning. Such proposals that consist only of a final formula usually involve further work for the recipients to get to understand them since the steps taken to derive them are omitted. Presenting a proposal like this shifts the burden of initiating understanding work to its recipients, which risks the danger of being dis-attended when the recipients fail to do so.

From recipients' ride, presented with two proposals, no elicitation for elaboration or explanation, such as a question, is made. Davidcyl seems to be eager to present his own proposal that appears to be relatively well-thought and well-presented and he simply opts not to unpack the work underlying the two similar formulas. Confronted with a competing proposal, Jason makes a dismissive comment.



Formula for total number of sticks

$$N * (N+3)$$

Figure 4.6.3

The ways both davidcyl and Jason take up a competing proposal from each other's are similar in that they both stress on bring up their own proposal but without explicitly problematizing or challenging the other's, or in other words, attempting to under other's. Jason does not produce elaboration or explanation on his formula but instead presents an argument that suggests his formula be accepted. This argument seems to treat that whether a formula "works" is what to be considered to choose among competing proposals. In the subsequent sequence, davidcyl performs some operations on his math expression, for which he displays the steps and a simplified expression is presented as a result that appears to the same as Jason has presented and insisted. He quickly acknowledges this by producing a positive assessment to Jason's proposal. The conflict between the two competing proposals seems to be resolved since the "convergence" reached is treated as unproblematic and the sequence on the topic of number of sticks is subsequently concluded: Jason acknowledges davidcyl's assessment (with appreciation, conveyed in a smiley face emoticon); the 20 seconds elapse and Jason's initiation of a new topic mark that the sequence is considered as concluded.

† davidcyl 5/9/06 6:35:03 PM EDT: this simplifies to $n(1+n) + 2n$,
or $n(3+n)$
davidcyl 5/9/06 6:35:09 PM EDT: so jason, you're right
Jason 5/9/06 6:35:16 PM EDT: 😊
Jason 5/9/06 6:35:36 PM EDT: so now onto a formula for the
total number of squares

Excerpt 4.6.8

As analysts, if we take a "privileged" view to look into this sequence of interaction, other than viewing it as how participants oriented themselves to attend to these actions, we come to notice that the sequential position of 137's proposal in the sequence, i.e. following the check work he has performed, may bear to inform how the formula is derived and connected to the ongoing work. If this is the case, then his tentative proposal is probably based on generalizing the pattern of how the numbers grow, which is certainly a plausible and promising approach worth exploring for the group. Similarly, although Jason does not provide any information on how his formula is derived, we know that he has been oriented to finding out the pattern for the number of the sticks since the beginning of this sequence. He has presented a few steps that suggest an approach of deriving the pattern by observing the pattern of the growth of numbers (in contrast to davidcyl's orientation to the graphic representation of the problem). The formula is probably a result derived from this approach. However, we see that these ideas with potentials are not explicitly presented or explained. Neither do recipients demonstrate their understanding, or question or elicit underlying reasoning of what's been presented. This also appears to be the case when they present an alternative one and *dismiss* the other, which means that they do not produce an *account* for not pursuing the current one. Even when facing conflicts between competing proposals, participants choose not to explain. Although something resembles some "convergence" is reached at the end that seems to resolve the conflicts, Jason's approach from which his formula is derived is still left unexplained hence probably inaccessible to the group members. Understanding as social interactional achievement is public, available for examination thus "accountable" (Garfinkel, 1967). When understanding is not displayed, it turns out to be problematic

whether participants have achieved shared understanding. As our data shows, ideas get dis-attended and lost.

We have noticed that davidcyl, however, when presenting his ideas earlier on finding the patterns of how the number of squares and later sticks grow, has employed a contrastingly different way to that of both 137 and Jason. He first tries to orient others' attention to what he is about to present. For example, at 6:29:31 and 6:29:39, he sets up the projection that an approach "to find the number of sticks" is about to be introduced and orients others to the whiteboard from the chat area. Secondly, his proposals are made in complete sentences with one setting up for the next or building upon a prior, such as by using "and" prefacing, which can constitute and maintain activities across sequences (Heritage, 1994). They are presented step by step exhibiting the underlying reasoning. Besides engaging others to do "understanding" what's being presented, explicating the steps could also involve others in participating and contributing to the process of solving the problem. We see that the thread initiated by davidcyl on the number of squares is selected by 137 to take up (at 6:28:16) by performing a manipulation of the presented math expression, which turns out to be what exactly davidcyl presents as the next step, showing the co-construction of problem solving steps between participants. In the subsequent posts, 137 presents his approach of finding the number of sticks and the result he has got, which makes use of what has just been derived – the formula of the number of squares – as well as the graphic representation created by davidcyl (i.e. counting the "overlaps" on the diagram). The formula of the number of squares thus has become a *shared knowledge artifact*, so has the graphic representation served as *shared resources* for their problem solving task. This demonstrates to us the process of *knowledge building* that participants have engaged in doing.

CHAPTER 5. DISCUSSION

In this chapter we first summarize the findings of our analysis in relation to the issues we raised. Then we discuss the methodological and practical implications of the study for CSCL and information science research.

5.1. Conclusions

We have structured our dissertation around the following two research questions:

RQ1: How are troubles of understanding with respect to mathematical concepts, reasoning procedures or problem solving introduced and made relevant to the ongoing interaction in the group?

RQ2: How are the introduced troubles dealt with in the group and how is shared understanding co-constructed?

5.1.1. *Three kinds of troubles and methods to introduce them*

From our analysis, we have found that the troubles of understanding pertinent to math problem solving in small groups seem to fall under three main types, namely, troubles affiliated with epistemic differentials, problems of indexicality, and conflicting understandings.

- I. “Epistemic differentials” refers to the situation where a participant or multiple participants display to each other what can be glossed as “a knowledge deficit” with regard to (a) certain math concepts or (b) work presented by a member of the group. In this situation, some participants demonstrate local expertise while others demonstrate in particular ways that they are locally “less knowledgeable” with respect to a matter of local relevance.
- II. The second type of troubles, “problems of indexicality,” refers to troubles caused by referential problems when something being referenced has not been adequately identified for interactional use for all relevant parties.
- III. Troubles of the third type, “conflicting understandings,” arise when one or more participants demonstrate their understandings as different from those of other participants with respect to some math topic.

We have found a certain set of methods for introducing such troubles which include a) pose a question; b) make an assertion; and c) make a self-report. Those methods are frequently associated with a particular type of troubles. For example, indexical problems are routinely produced as such with a question designed to elicit an elaboration, explanation, or demonstration from the actor who initiated use of the referential term. Such inquiries treat the initial user of a term as being accountable for producing an

explanation or elaboration. However, when an actor perceives the matter as something that he or she as a competent member should know but does not, actors tend to use reports to initiate understanding work. Additionally, when one problem of understanding is resolved, actors may produce a related problem of understanding of a different sort. For example, a problem may begin as an epistemic differential or a problem of indexicality and subsequently become a problem of conflicting understandings. Alternatively, a problem may start as a problem of conflicting understandings and end up becoming a problem of epistemic differentials, etc.

I. Pose a question

One common way that participants initiate troubles of understanding is to pose a question that elicits:

- information on some math concept to which previous reference has been made, or
- explanation of or elaboration on the idea or work that has been presented by others.

Questions hold the recipient accountable for producing a response (Schegloff, 1968; Heritage, 1988). Questions are ways that understanding problems can be organized as a problem of reference where the source of trouble is some term that has not been adequately identified for interactional use for the questioner.

In a peer group like VMT, introducing troubles can be a delicate matter. When a member's math competency becomes a relevant matter, we see participants skillfully initiate such troubles using various strategies. A participant can design a question to introduce troubles while constituting and managing his or her relationships with others. An actor can demonstrate competency by making inquiries of various sorts. We have found participants employ the following methods to demonstrate competency:

1. Elicit an assessment of a candidate understanding of a matter previously put forward by another actor
2. Solicit a "reminder" of "forgotten" knowledge
3. Make a request for a demonstration
4. Provide information on what one already knows regarding the matter as a preface to a question

All these methods involve designing a question for which the response is projected to be relatively unproblematic to produce. Such questions call on recipients to produce particular responses, such as assessments, elaborations, explanations, or demonstrations. Initiating a problem of understanding that calls on recipients to engage in instructional work is rare in VMT data because instruction calls for an organization of participation in which an actor's standing as a peer of other actors can be questioned, challenged or treated as problematic.

- If the candidate understanding of a matter previously put forward by another actor is treated as correct, then the matter is treated as understood (Stivers & Robinson, 2006; Schegloff, 2007); otherwise, an explication of the questioned matter is presented.

- As regards method 4, providing information on what one already knows regarding the matter before posing a question helps the answerer to rule out possible sources of trouble (Pomerantz, 1988).
- When a question is not specific enough, it may call upon recipients to work to discover the trouble source and/or engage in instructional work with regard to the matter at hand.

In our analysis, we use case studies to show how a question is constructed and how it is taken up in the group. We have explicated the basic sequence structure when a candidate understanding is used to initiate trouble as well as its variations.

II. Make an assertion

Assertion is another commonly used method in VMT groups to introduce troubles that are related to conflicting views or understandings (or disagreement). It calls into question another actor's understanding by presenting an alternative or candidate understanding. An assertion often comes after a question-answer sequence when an explanation is produced to address the trouble introduced. Reversed Polarity Questions (RPQs) (Koshik, 2005) are often used to convey an assertion that calls for the recipient to produce an account of the mathematical matter that the assertion is challenging (Heritage, 1988). Such a challenging or problematizing move can lead to explicit displays of reasoning. Sometimes alternative proposals are made as a way of resolving the differences made evident by RPQs.

III. Make a self report

Being able to ask certain kinds of questions regarding a trouble source requires a certain amount of competency. When participants lack such competency, they resort to other methods to

- present their troubles to recipients and
- position themselves as peers to mitigate any epistemic differentials.

There are a number of interactional methods by which an actor can display a trouble of understanding when he or she lacks the competence to produce a question. One method is to make a self report by which one displays the status of one's own math ability or understanding. Such reports can serve to elicit (a) some form of instruction from a recipient or (b) inquiries from recipients in the form of questions about the reported trouble (Zhou, 2009). This shifts the burden of formulating a question to the recipients from the questioner. Such strategy is also used when asking a question risks interrupting the flow of the ongoing conversation on the current topic, so a report serves to set up the context for a question to come.

A self-report commenting on the speaker's math competency or understanding status also does the work of "bracketing relationship", by which we mean that a participant explicitly brings up the relationship issue – the matter of competency – in order to set it aside so it would not be attended to at the moment. Such actions avoid the relationship issue being brought up by other members which is part of the means by which peer relationships are maintained. This strategy is observed being widely used by participants when initiating the troubles of understanding such as in designing a question.

Other methods to introduce troubles when lacking competency of producing a question include:

- a) Presenting what one knows as a way to elicit information on what one does not know without asking a question explicitly eliciting information about or explanation of the matter
- b) Engaging others in the group to elaborate so opportunities may rise for putting out a competent inquiry

5.1.2. Participation

Different methods do different work to position participants as more or less knowledgeable actors. These methods are used to allocate rights and obligations among participants and organize participation in the ongoing interaction. Our analyses also show how participants move from one method to another. Occasionally actors escalate their requests for assistance with a problem of understanding, initially using an implicit formulation of a trouble (such as a self-report regarding one's understanding) and subsequently using more explicit methods (such as a direct question or request) if implicitly produced requests are not addressed. The inquirer who initiates the trouble can display or demonstrate his understanding of what has been explained. Our analysis shows that methods to do this include making a self-report regarding the achieved understanding on the matter of concern, applying what's been explained to the problem solving and performing the next step, or reformulate what's been explained (Garfinkel, 1967). Question-response interactions are key to pursuing group problem-solving strategies (Zhou, Zemel, & Stahl, 2008), building a joint problem space and sustaining the team discourse. Questions are ostensibly posed by participants for information seeking or help seeking by individuals. As revealed in the analysis, the question-response pairs also function at the small-group level as mechanisms for managing peer relationships and organizing participation. They can function to include—or exclude—a member. They can play an integral role in the social relations among the participants, positioning individuals as more or less competent and maintaining or adjusting peer standings.

5.1.3. Co-construction of trouble and collaborative nature of response

Another interesting finding related to the setting of collectivities engaged in collaborative problem solving is that often the trouble is initiated and constructed by multiple participants. Additionally, the reported trouble is often attended to collaboratively. Our analysis has illustrated a few cases where such co-construction of a trouble noticeably happens:

1. An inquiry is co-constructed by elicitation of a question in response to a report made where the participant with the trouble is not able to articulate a question and a question is only constructed through a group process with other's help.
2. An inquiry is co-constructed by intervention from another participant upon a "failed" question. When a shared trouble is raised by another participant, one waits to see how it is being addressed before trying to present it.

3. When facing troubles understanding some presented work, instead of asking a question, a participant prompts another group member to do so.
4. Trouble shared by multiple participants is expressed by a second participant following the first participant's action of making the trouble evident. This expands the trouble to a more significant one that the group needs to deal with before proceeding.
5. Participants attend to the trouble together and build on each other's contributions.

5.1.4. Co-construction of shared knowledge artifacts

System affordances (text postings, drawings, referencing tools, awareness information, etc) available in the VMT environment are used both to introduce troubles and to address them. Referential resources are created as results of dealing with troubles caused by referential problems. They are being used by group members to do understanding work. Shared knowledge artifacts are also constructed as collective knowledge of the group, which are referred to and made use of later in the session or for solving different problems. They constitute evidences of shared understanding.

5.1.5. Math questioning and competency⁹

In the VMT Project we invited students to come to chat with their peers in small groups about non-routine math problems designed for them that we thought might be interesting and might encourage mathematical thinking. Different from tutoring sessions, VMT chats stress peer interaction among students and collaboration working on a math problem. We all know that competence in a particular matter is not always distributed equally among participants in an interaction. The chat setting makes the study of this possible because subtle displays of one's own competence or of attitudes toward the competence of another possible through body language in face-to-face settings must be made more explicit online. In VMT, some groups may consist of students from different grade levels; participants may or may not have experience in prior VMT sessions; some may have looked at the problem and tried to solve it before they joined the chat while others have not. In terms of competencies, we notice that some students display higher mathematical fluency, e.g. working with equations; some are better at verbally expressing themselves while others are better at conceptualizing problems visually. Even though many of the differences in expertise, talent, ability, knowledge, understanding, etc. may exist, not all of them are made relevant to the interaction. Differences only become relevant to the organization of participation in the group when they are made so by participants, which can be done in a variety of ways. In other words, it is the local and situated differences that are of interactional relevance. The issue of relative competence often interacts with the student questioning processes.

⁹ Discussion regarding this issue has been included in Chapter 8: Question co-construction in VMT chats in In Stahl, G. (Ed.) *Studying virtual math teams*. New York, NY: Springer.

Through our analysis, we are able to explore how it is possible to sustain a productive peer relationship in an online group when there are relevant differences among actors in expertise, talent, ability, knowledge, understanding, etc. Pursuing this line of inquiry allows us to look into the mechanisms underlying peer-group interaction. How such group mechanisms may support or inhibit individual learning has become an important topic for current research on learning and instruction (Barron, 2003; Cohen *et al.*, 2002; Schwartz, 1995). When there are differences in competence, actors need to work out among themselves the social order and the organization of their interaction. We have looked at how differences are attended to by participants in a collaborative peer group as part of the mechanism by which a group of students collaborate and manage the organization of their participation in ongoing chat interaction around problem solving. In particular, we examine the ways members of a small group (a) introduce differences in situated competencies as interactionally relevant, (b) organize their interaction to attend to these differences and (c) effect repairs where possible or find ways to proceed where repair is ineffective.

There are many ways that differences in competency can be introduced as interactionally relevant. Posing a question to initiate some troubles of understanding is often one way of accomplishing this. For example, an actor can ask a question about what is going on, or indicate there is a problem of understanding, or the actor can show the need for assistance by taking a particular kind of “next step” in a sequentially unfolding set of actions, etc. Acting as less competent than others does not mean the actor is not “membered” (Garfinkel & Sacks 1970) as a participant in the ongoing interaction. It means the actors have constituted as relevant a particular difference in the distribution of presumed or actual competence among themselves. When a questioner asks certain kinds of questions, she constitutes and makes relevant differences in expertise, knowledge, etc. as a matter for the recipients to attend to. Thus, not only is the questioner asking a recipient about the matter at hand, she is also instantiating their relationship in terms of the organization of their participation in the interaction (e.g., as questioner and answerer). In examining our data of students’ interaction in VMT chats, we have noticed that *question-response pairs* are frequently invoked for attending to differences in local expertise and competency. For instance, asking a question may imply that the addressee(s) are likely to be able to provide some information that the questioner does not know.

When actors put forward certain questions that do not address explicitly their standing as participants in the interaction, matters of difference in knowledge, understanding, expertise, etc., can be addressed in ways that preserve a peer relationship between questioner and respondent. When actors make the organization of participation explicit in the question-response construction as a matter to be addressed, then the nature of the relationships among interactants becomes a matter of concern that needs to be addressed. Issues of differences in knowledge, understanding, expertise, etc., are then made relevant in terms of the way those relationships are worked out. Thus, one way that actors maintain peer relationships is by not addressing potential differences in competence explicitly as an interactional issue in question-response interactions. Our case studies show how actors *build a question and build a response* that allows the questioner and the

respondent to attend to their relationship by addressing the matter at hand rather than by explicitly mentioning their relationship itself.

5.1.6. The local situated nature of “question”

Questions and responses are used to perform a variety of actions depending on their design and the circumstances of their use. In the episodes we have analyzed, questions posed by participants in a small group do various work in their collaborative problem solving. Our analysis has shown how questions are used for organizing participation, coordinating group process, establishing common ground, seeking information, doing understanding work, etc. Often one question does multiple kinds of work. Questions provide various resources in their design and production that reify epistemic relations among participants. They are performed in ways that constitute actors as participants of various sorts, i.e., determining who can ask questions and who are entitled to respond. Questions situate actors in a scene in relation to each other by making evident who acts, of what those actions consist, and the provisional entitlements of actors to participate in the performance of those actions. The entitlement to produce questions and responses is a matter of interactional significance to participants. Questions play an important role in participants’ understanding work. As demonstrated in our analysis of some cases, participants apply what has been explained to the problem and display the achieved understanding for assessment, providing opportunity to reveal problems of understanding and engage in further understanding work.

Questions and responses do not just happen. There are various methods participants use to design and produce a question. Participants make use of various available resources to make evident to each other the adequacy of the question and response, e.g.: the shared history of the group, what has happened in the session recently before, what possibilities for response the previous action projected, awareness information of the production of an action, the existing postings and activities performed on the shared whiteboard, etc. In the VMT chat environment, postings are not meant to be “heard,” but “read.” The texts in the chat and artifacts on the whiteboard are contingent, situated and produced to be interactional resources. A question on its own would not make sense to participants nor to researchers unless put in the local context and treated as a locally produced situated social phenomenon. It defines its meaning through the interaction among participants, and is interactionally accomplished.

The uniqueness of the interactional setting built up as the interaction takes place is consequential for how participants produce questions and responses and make sense of them. In the VMT environment, the shared whiteboard, the referencing tool and the social awareness information accord participants resources for organizing their interaction and participation. The chat and whiteboard are used in a coordinated and integrated way to produce the explanations that a question is calling upon. The fact that there are more than two participants and interaction is mediated in a chat environment shapes the way interaction takes place. Our analysis shows that a question-response pair often takes more than two or three turns to complete. Questions often lead to sub-questions that call upon sub-responses—a question-response pair can have nested sub question-response pairs.

Question-response interaction often goes several rounds during which a question is reformulated based on responses given and responses are produced by drawing on information from the detailed formulation of the question about what is known and what needs to be known by the questioner (Zhou et al. 2008). This is different from theories that treat questions as predefined and seeking a well-defined answer or a piece of information. Rather, question and response are local situated social phenomenon.

Our analysis has also revealed in particular that questions calling for accounts of problem-solving work are different from “pure information questions” as traditionally conceived. They are not simple inquiries where sought information is directly provided as some static object. Rather, they call on elaborated explanations or accounts. As participants collaboratively engage in such productions of accounts, they make meaning of what has been presented together. Such questioning initiates understanding work. Although the questioning actions analyzed in this dissertation work are utterly situated and must be analyzed as unique case studies focused on interactional sequentiality, we have found the structure of such practices of questioning to be typical within our corpus of online math discourse. Making math proposals, raising questions, responding with nested questions, providing accounts and reaching conversational transitions are driving mechanisms for the interactional progression among students in the virtual learning world created by the VMT project.

5.1.7. Competent questioning

Math proposal adjacency pairs as a particular kind of adjacency pairs of interaction have been studied within the VMT Project. In particular, analysis of a “failed proposal”—in the form of a question—suggested some characteristics of successful proposals (Stahl, 2006). Drawing on this, we have contrasted a “breakdown” example of a question-response interaction to a successful case in an attempt to pull out what a “successful question” may consist of (see Section 4.4). Our analysis suggests the following characteristics for successful questions, some of which bear resemblance to those for successful proposals:

- (a) *A clear question structure that elicits a response.* Making a report of one’s math competency may indicate some problem of understanding, but not present a question of its own. It does not elicit a response from the group. A question on a math topic with a clear structure is more likely to elicit a response without interactional trouble.
- (b) *Information on what is known by the questioner.* A response to elicitation for a question such as “*the derivation of the number of squares*” may be ambiguous as to what it is really asking for as there are multiple possible readings of it, such as the derivation by the group through a sequence of inquiry moves or the derivation of the pattern as a mathematical proof. Providing information on what the questioner already knew can help rule out some possibly readings of the question, such as “*n=3 is 3+2+1 squares, n=4 is 4+3+2+1 squares... how did you get $n(1+n)/2$?*”. This may be particularly important for successful question-response interaction in a small peer group, in that such information also demonstrates the questioner’s competency as being a member of the peer group.

- (c) *Right timing and interactional context within the sequence of interaction.* Posing a question irrelevant to the ongoing discussion takes the risk of interrupting the group and deviating from the topic; careful work is needed to build the context for the question, and this risks failure.
- (d) *Engagement in the group process.* Indication of being engaged in the group process is also helpful in that it contributes to enacting and maintaining the peer relationship. For instance, in the case study we present in section 4.4, being attentive to the group's effort on catching him up demonstrates the participant Jason's understanding of the work the group did. It helps rule out alternative meaning of the subsequently posted question. Failing to engage in the group process like Nish does during the response construction is destructive to the peer relationship. Once the peer relationship is not maintained, the group stops the effort of addressing the question and the entitlement of asking further question on the same topic disappears.

5.1.8. Understanding work vs. lack-of-understanding work

We have also noticed that the practice of introducing troubles such as questioning (or understanding work) does not always happen even when it becomes evident in later interaction that such troubles do exist. We present two case studies on the analysis of the lack of "questioning" or initiation of trouble in which we explicate the ways that a posting or contribution gets dis-attended by participants (Zemel, Zhou, and Stahl, 2009). The analysis is presented in order to contrast with cases where "questioning" does happen and participants are very engaged in doing understanding work. Through our analysis, we have come to a better understanding of how understanding work does or does not happen in a group. Lack of initiation of trouble is understandable considering that face issues are always a concern in a peer group and revealing one's trouble has the potential risk of breaching the peer relationship. The fact that there are ideas from different members competing for attention of the group also seems to contribute to it. Some members are not necessarily adapted to the concept of "working together" on discussing a math problem, as we have observed in their interactions in their first sessions when they are new to such experiences. The VMT environment that consists of chat and shared whiteboard as dual interactional spaces also allows contributions to get ignored. Facing those challenges, one way of initiating potential troubles is that the idea presenter tries to engage others to do understanding work. One may pose a question explicitly eliciting an assessment of what has been presented or a report on recipients' understanding status. This puts the recipients in a position of offering assessment; if they are not capable of doing so, they may produce a question eliciting explanation or a report revealing the trouble.

5.2. Significance and Future Work

In this section we will reflect on some of the implications of the findings of our analysis and case studies and the discussions above.

5.2.1. Extending the theories of information behavior

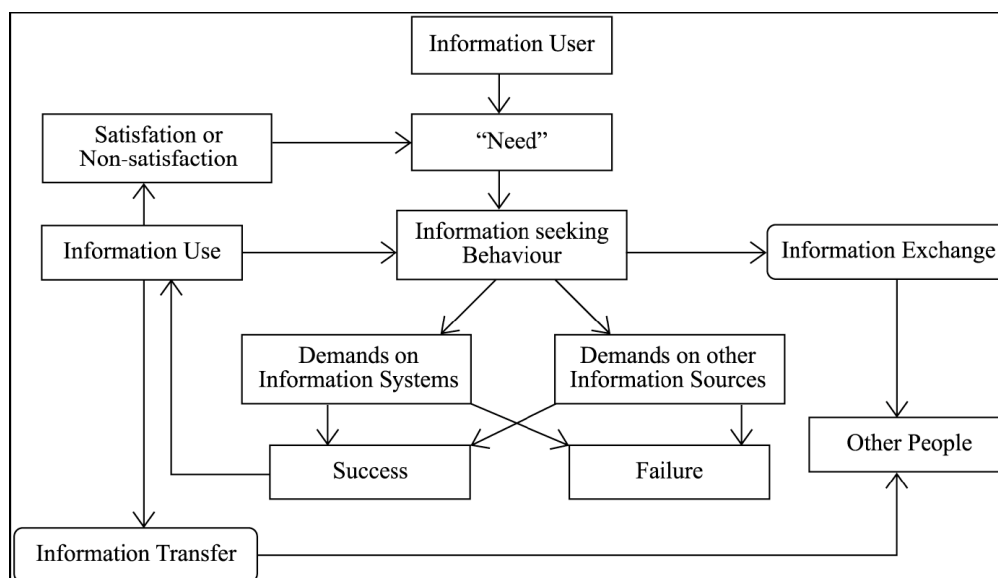


Figure 5.2.1.1: A model of information behavior

(Adapted from Wilson 1999: *Models in Information Behaviour Research*, Journal of Documentation, 55(3))

One of the major motivations for the dissertation work we have reported here is to contribute to the existing theories and studies on information behavior, a well-studied line of inquiry but with a few less explored areas. Based on our reviews of the current research, we have come to identify those areas roughly as “information need”, “information user”, “information exchange (with other people)”, and “information use” (see Figure 5.2.1.1), which are constructs conceptualized in the field of information science. Information need is a cognitive construct that is sketched to capture what triggers the behavior of information seeking. Current theories argue that when people are in a problematic situation (Belkin, Seeger, & Wersig, 1983), or realize there is a knowledge deficiency to solve a problem (Belkin, 1980) or bridge a gap in understanding (Dervin, 1983a; Itoga, 1992; Dervin & Nilan, 1986), they are in need of certain information. In an effort to provide an explicitly cognitive explanation of the general phenomenon of “information need”, a hypothesis of the *anomalous states of knowledge* (ASK) to characterize that information needs are not in principle precisely specifiable is proposed (Belkin, 1980). The cognitive viewpoint taken by the theories on information need and theories on information behavior that build upon poses methodological difficulties for studying the phenomenon. The processes of “information use”, a probably mostly neglected area in this line of inquiry, has been left in a “black box” (Savolainen, 2006) in the current research. Our work on analyzing how troubles of understanding are initiated and attended in small groups offers an EM/CA (ethnomethodological conversation analysis) approach to investigating “information behavior” in group settings. The ethnomethodological approach to the analysis of action and its rationales is premised on the public accountability of action (Garfinkel, 1967). It is the procedural basis of action which bridges the gap between cognition and action, both practically for the actors and theoretically for the social scientists. Instead of treating “information need” as something

given that triggers the behavior of information seeking, such method focuses on participants' orientation to the problem and take close examination of their practices. By looking into how troubles are initiated, we come to understand how "information need" is negotiated and (co-) constructed among members of the group. From our detailed analysis, we show various interactional methods by which such troubles are constituted as such and procedures involved by which the troubles are attended and resolved.

EM/CA also offers us an approach to understanding "information users" by allowing us to examine their actions and practices. This is different from traditional approaches that have been recurrently applied in the research on information behavior, which usually distinguish certain groups or populations of users and tend to treat that the same "category" of users share the same practice (or "behavior" in "information behavior" term). Such researches usually are oriented to identify characteristics of users and use them as variables to explain certain "patterns" of behavior. In contrast, EM/CA holds the notion that "the organizations of practices – as the conditions on which the achievement of mutually intelligible and concerted interaction depends – are fundamentally independent of the motivational, psychological, or sociological characteristics of the participants" (Heritage, 2008). Rather than being dependent on these characteristics, conversational practices are the medium through which these sociological and psychological characteristics manifest themselves. Our work also demonstrates how "collaborative information behavior" – in our case, information behavior of online small group engaged in math problem solving – can be approached from an interactional perspective by looking into the interactions that participants engage themselves in.

By looking into the phenomenon of how troubles of understanding are initiated and attended in a collective, we are able to examine the processes of meaning-making by which meaning is co-constructed as an interactional achievement. We have demonstrated how "information" in the settings of collaborative learning should be treated as a *process* rather than an object or a container that contains "information content" that could be transferred between the sender and the receiver. This extends the theories on how information should be conceptualized, a contentious topic that has been sitting on the center of our field of information science. Although researchers have realized that there can be various ways of conceptualizing "information" and their consequential methodological commitment, most theories and studies on information behavior nevertheless tend to treat "information as a thing" (Buckland, 1991) and naturally apply research methods that treat information as given, which in our view, greatly constrains how much can be revealed of the "real" phenomenon of interest. "Information as a process" has first been proposed by Buckland (1991). In her communication model of Sense-Making that considers information seeking as "bridging the gap" (Dervin, 2003), Dervin also talks about "information" as a verb and proposes making no distinction between knowledge and information. Those theories offer great insights to our way of thinking of information although they fail to offer the methods that would allow researchers to get hold on the phenomenon. In our analysis, we show "information" is not something that can be simply offered to the participant who has trouble of understanding, or in other words, has the "need for information", and the trouble can be resolved. Rather, by attending the troubles initiated as a collective, participants develop a set of social

practices for *doing* this. It is through the shared methods and procedures that shared meaning is produced and accomplished. So when we talk about information as a “process” and possibly information as “shared meaning”, we talk about the *common methods and procedures* through which shared meaning is accomplished. The analysis we presented demonstrates how powerful EM/CA as a research tool to allow us to address the methodological difficulties the studies of information behavior have long facing.

5.2.2. Contribution to CSCL and Learning Sciences

This research also contributes to extending our understanding of questioning and explaining in peer groups, which are considered as important areas of research for learning sciences and CSCL in particular. Prior researches that are explicitly focused on the two topics tend to take an orientation from “objectivism” and “structuralism” that they follow theories such as linguistics or the Speech Act Theory. “Questions” are treated as given and have the internal structure that determines its “meaning”. Therefore, research questions are organized as “what kinds of questions do students ask?”, “which questions are more effective on learning outcomes?”, or distinguish “high-level” vs. “low-level” questions according to their linguistic characteristics. We move forward to research interests that are oriented to the interactions taking place and the processes by which “questioning” or “explaining” is accomplished. Such orientation allows us to answer “why” questions that are not attended by prior studies, which present some findings of correlations among variables related to “questions” and those related to “learning outcomes” or “performance”. We show how question is an interactional phenomenon that is situated and locally organized. Its production may involve several rounds of question-response pairs during which a question is reformulated based on the response received. Questioning is also a social practice where institutional settings, rights and obligations of being a “peer”, shared experiences, and so on come into play. In the particular setting of collaborative learning that the study is situated in, we are able to analyze questioning and explaining in a small group of 3 or 4 participants. We have interesting findings on how questioning and explaining are accomplished as collaborative efforts of the group.

Meaning-making is considered as a central theme of the field of CSCL. Attending troubles of understanding is one important aspect of collaborative learning where “understanding work” takes place and shared meaning is constructed. Through our analysis of how troubles are initiated and how they are attended, we come to see how collaboration happens and what learning may consist of. For example, we see a method for solving the problem is proposed for which the recipients have problems understanding, explanation is produced and the method becomes a shared knowledge artifact that is reused later. It is through the process of initiating and attending troubles that shared referential resources are constructed and shared understandings, which are the procedures for producing them, is produced. They are accomplished as collective efforts. By contrasting cases where such understanding work happens and those where understanding work seems to lack, we are able to see better what “good collaboration” is and what may lead to learning.

For the practical concerns of the VMT project, this dissertation work provides understanding of the interactions taking place in the VMT sessions, particularly on those organized around attending “troubles”. From the perspective of moderating and mentoring services, our findings provide us some solid evidences for what consists of good collaboration and whether there is “learning”. They can be utilized for providing feedbacks to the team’s session in terms of how well they collaborate, how they get on with problem solving, etc, or intervene during the session when necessary, and design task for the teams to promote more productive collaboration and deep understanding.

5.2.3. Contribution to conversation analysis

The dissertation work we presented adds our understanding on “repairs”, a topic in conversation analysis that looks at the organization of repair when problems in speaking, hearing, and understanding occur. Current conversation analysis researches on repairs are mainly focused on mundane conversations taking place in face-to-face situations or through phone. Our work extends the study to the domain of math reasoning and problem solving, and “conversations” as in computer-mediated communication (in the VMT chat environment) where some fundamental mechanisms for conversations are significantly and noticeably different. It also contributes to the body of knowledge about the design of questions and answers.

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