

## Chapter 11

# Student and Team Agency in VMT

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**Abstract:** Agency is inherently a central concern for constructivist education. CSCL researchers need to think about the effectiveness of online learning environments in terms of how they encourage student groups to take active control of their learning activities. This chapter draws on the anthropological, psychological and sociological traditions and their concept of *agency* in order to consider the relationship between individual and group agency and to understand the differing constraints on interaction in classrooms and online. It then investigates agency in sessions of mathematical discourse in the VMT chat environment. Our empirical discourse analysis displays instances of significant agentic behavior and our theoretical review suggests that there are structural features to the VMT online environment that encourage agentic behavior on the part of students, individually and as a group. This has important implications for understanding learning and for designing pedagogic activities.

**Keywords:** Epistemic agency, group agency, structuration, habitus, positioning

Computer-supported learning comes in many forms and hybrids. There is the notion of computer-supported collaborative learning (CSCL), computer-supported community-based learning (CSCBL), and so on (Shumar & Renninger, 2002). Enactments of such learning opportunities apply to students from primary school to university; they refer to formal and informal learning such as after-school and community center programs, and to online, face-to-face or blends of these. In all these forms computer tools and artifacts are used to create activities for intellectual exploration and to promote social interaction (Stahl, Koschmann & Suthers, 2006). CSCL activities are designed to engage students in learning through jointly

negotiating and planning how to proceed, generating questions and exploring possible problem solutions. In collaborative processes, students model and scaffold learning for each other. In short, learning in CSCL environments calls for self-directed or group-directed processes and is dependent on social and psychological mechanisms that support and sustain learners' willingness to collaborate and engage in productive interaction. The motivating force that drives the decision to engage with others to produce shared meaning and build common understanding (i.e., common ground or a joint problem space—see Chapter 6) can be characterized as *agency* (Greeno, 2006; Schwartz, 1995). The primacy of agentic actions in collaborative learning is such that Scardamalia and Bereiter (Scardamalia, 2002; Scardamalia, Bereiter & Lamon, 1994) view them as a guiding principle (“release of agency”) in the design of their knowledge-building communities.

In this chapter we use the concept of agency to frame our analysis of students' collaborative participation in the VMT Project. Agency as a concept helps us understand the relationship between structural (including technological) constraints of the VMT environment and the actions of the student participants. This in turn informs our thinking about the strengths and weaknesses of these kinds of online environments for developing a sense of identity, competence<sup>1</sup> and self-efficacy. The aim of this chapter is to examine ways that students exhibit agency in the VMT environment. In the process, we shed light on how such actions interact with the affordances of the environment to promote learning.

While online environments like the VMT chat environment lack the bandwidth that meeting face-to-face might have, we have noted the affordances of the environment are such that they tend to support a more focused conversation around mathematical problems and objects. Further, part of the research at VMT has been to develop an environment that has a chat space, a workspace and referencing tools to make it easier for workers in the space to point things out to each other and keep track of their work (Chapter 15), overcoming some of the limitations of standard chat media. This seems to have yielded an environment that can support small groups very focused on mathematical conversation—perhaps more so than a traditional classroom with its many distractions. If this potential exists, then the question of how individuals and groups act—and act in ways that are independent of the cultural and structural forces they feel around them (agency)—is an important question in understanding learning and the development of new knowledge. Before moving forward let us briefly situate agency within the CSCL literature.

## **Briefly Defining Agency**

Most notably, the notion of agency has been the focus of work conducted by Scardamalia and her colleagues (Scardamalia, 2000; Scardamalia & Bereiter, 1991;

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<sup>1</sup> Our definition of competence involves development in one's ability to better use resources and opportunities. This includes making full use of opportunities to practice thinking and cognitive skills (e.g., attending, selecting, monitoring) in the course of communicating with others (or self-reflecting) toward some mutually agreed purpose, such as problem solving.

Scardamalia et al., 1994). In the course of observing students' use of CSILE and Knowledge Forum, she coined the term *epistemic agency* to describe the acts of initiative taken by students—very young in some cases—to present their ideas and to negotiate a fit between personal knowledge and the knowledge of others, “using contrasts to spark and sustain knowledge advancement rather than depending on others to chart that course for them” (Halewood, Reeve & Scardamalia, 2005, p.2). In taking on responsibility for aspects of their own learning and developing competency, students demonstrate their epistemic agency, for example setting goals, self-evaluating and doing long-range planning. Accordingly, Scardamalia (2000) views epistemic agency as one of the two major components of productive engagement. From the collaborative-learning perspective, epistemic agency implicates the students' willingness to see themselves as members of a community, hence supporting their community identity. Community identity and epistemic agency are seen as mutually constituting the students' engagement in community discourse (Brett, 2002), along with the development of requisite competencies. We will return to this line of reasoning below.

What is unique in our approach to agency is that we introduce communication as a component and focus on its role as the mediating device, connecting individuals and concepts on both social (group) and cognitive (individual) levels. Such ideas are similar to the thinking of scholars such as Greeno and Sfard. Greeno (2006) talks about the distribution of agency, which might be akin to distributed cognition (Hutchins, 1996) but involves the ways in which individuals can and do contribute to collective thinking in collaborative activities—much as do group cognition analyses in this volume (e.g., Chapters 5, 26 and 28). In the process, he introduces notions of positioning, which we will discuss in more detail shortly. Sfard (2008), in her work on mathematical learning, suggests there is an intimate connection between the communication of mathematics and mathematical thinking. She refers to this unity of communication and cognition as “commognition.” In a recent review of Sfard's new book, Stahl (2008) discusses how for Sfard thinking and math objects are themselves products of the discursive process. These “reifications” that get objectified and internalized by individuals come out of interaction and are re-introduced into interaction. These are critical points for us because they raise central questions about the value of online working environments like VMT and also the importance of theoretical constructs like agency.

In the following sections we elaborate on agency as a theoretical construct by looking at how it is viewed in different disciplines. As a guide to reading this chapter we suggest that those readers who prefer to dive into data before looking at the theoretical perspectives skip ahead to the data analysis sections, and return to the upcoming section afterwards.

# Perspectives on Agency as a Theoretical Construct

## Structure/Culture/Agency

As a particular case of the larger Western preoccupation with determinism versus free will, sociology and the social sciences since their inception have tried to think through the relationship between structure, culture and agency. One interesting perspective on the structure/culture/agency triad is the thinking of the British sociologist Giddens. For him, structure is a product of the pattern of practices in which social actors engage; structure is emergent from human activity. Different levels of structure emerge out of different forms of human practice: signification, legitimation and domination. Signification has to do with the production of meaning, legitimation has to do with the production of moral order through norms and values and domination is produced through the exercise of power (Giddens, 1979; 1984). In Giddens' view there are rules and resources. From Giddens' perspective, rules are primary and they are the things that generate resources. It is the rules that shape the pattern of interaction, and then those interactions redefine the rules in a dialectical way. For Giddens the resources produced out of this dynamic forms what is for him the structure (Porpora, 1989; 1993).

The strength of Giddens' perspective is that structures are produced by human activity, but once they exist they then work to constrain future human action. Unfortunately, there are several weaknesses in the Giddensian model. Campbell (1998) has suggested that Giddens—like much of contemporary sociology—collapses a notion of action which would be personal action with the notion of social action, actions that are oriented toward others in a particular context. While there are problems with Campbell's view too, that are too subtle to go into here, there is an important point that agency is not just patterned action but can also be action that breaks with patterns and well-defined sets of rules. A second more critical problem of Giddens is his view of structure. While structure can be defined at a micro level as the patterns, interactions and resources generated in social activity, there is a larger level of structure that has to do with the more fixed sets of relations that people find themselves in, such as social class, race, gender, geographic groupings (Porpora, 1993). These larger structural forces play an important influencing role in how individuals “play the game of life” as it were.

It is this larger notion of structure that, in the French sociologist Bourdieu's terms, produces patterns of activity. Habitual action is structured through activity of the past but is then used to structure and classify future activity as well as things in the world. By combining the dialectics used by both Bourdieu and Giddens we may be able to see a way to overcome the primacy of either structure or agency and succeed in showing how dialectically they are the product of each other. Giddens adds a further dimension to structure and that is that people are conscious of their practices and so they engage with structure in a self-conscious effort to reproduce it or change it. So there is a reflexive quality to agency. While Bourdieu is also aware of this self-consciousness, he is much more interested in the way that most human practice is habitual or semi-conscious. Bourdieu is aware of the fact that social actors

often have a “strategy” for “playing the game” of life, but they are also often in his mind “shooting from the hip” (Bourdieu, 1990). This foreshadows ideas of improvisation that we will discuss shortly.

Giddens’ and Bourdieu’s understanding of the relationship between structure, culture and agency have proven useful for our analysis at both the level of the VMT Project itself and of the student interactions. From its beginning, the VMT Project has been a design-based development project. The practices of students using earlier generations of the chat environment influenced design decisions for future environments. The goal of the design team has been to enable future activity that students sought to engage in and to constrain activity that seemed to detract from the productive working together of the problem-solving teams. But also at the level of the activity of the participants themselves, solving a problem and interacting with the technology begins to build up a kind of small-group structure, which then carries through to the remainder of the session and may influence future work sessions of the same group. So looking at the micro interactions of structure and agency for a particular problem-solving team can help us understand how collaborative problem-solving works in this environment and how to further support team work.

### **Creativity/Imagination/Identity**

In a major article on agency, Emirbayer & Mische (1998) offer a critique of the Giddensian and Bourdieuan position. Essentially they argue that the focus of Bourdieu and Giddens is too much on structure and the production of habitual action and not enough on the creative emancipatory potential of human agency. The conflict between Giddens and Bourdieu versus Emirbayer & Mische involves a paradox in social theory. On the one hand, social theorists have to account for the dramatic patterning of human action and the way much human behavior can be predictable. On the other hand, they must also account for the production of new culture and the process of cultural change. These two realities are difficult to contain within the same theory and theorists tend to emphasize one pole or the other. Emirbayer & Mische by implication echo Campbell’s (1998) concern for the collapse of action with social action. Each of these theorists wants to preserve a space where individuals act out of their own sense of a personal meaning that is different than the forms of social action where meanings are oriented toward outsiders and one’s socially-defined identity. These ideas could also be compared to those of Cobb (2000), who draws on Gee (1992) in his efforts to think about how a mathematical identity is produced by interacting in a classroom. While of course all meaning, personal or otherwise, is produced in social contexts and is by necessity socially constructed, the distinctions they are trying to maintain are important. We want to be able to make a distinction analytically between the kinds of action that yield well-worn paths of activity that are taken up by large numbers of participants and constitute rule-driven behavior and those forms of action that come from some creative space that break the patterns of activity and forge new ground. Further, following Sfard (2008) and others, since these insights will be produced dialogically and in communicative interactions we want to be able to see this creative form of

agency (however rare it is) as both an achievement of individual persons and groups. And so it makes sense to see *individual agency* and *group agency* as different sides of the same coin.

Our hope then is to view agency as an act of creativity, which draws these two perspectives closer. Thus our definition of creativity does not fit with the standard psychological definition, focused on the isolated individual organism. We would argue that much of social life is constrained by cultures and structures that are both the result of larger material relations and the product of past action—both conscious and habitual—and that these constraints are something that social actors must indeed face. But, as we will discuss below, there are also creative potentials for social actors to engage with those structures in innovative ways. We feel that online services like the one the VMT Project is constructing in fact facilitate the creative and imaginative potentials when students attempt to deal with the constraints around learning math.

Holland, Lachicotte, Skinner & Cain (1998) also make an important contribution to the discussion of agency. They weave together the notions of agency and identity—thoughts that are reminiscent of Emirbayer & Mische (1998). They describe agency as mediated by identity; in turn, identity is shaped through activity in social practice and is the principle way in which individuals come to “care about and care for what is going on around them” (p. 5). What is different in their argument is that agency and identity, as mutually constitutive aspects of human interactions, are made possible through psychosocial mechanisms, i.e., improvisations and/or imagination (the creation of “*figured worlds*”). The former are creative actions mediated by individuals’ sensibilities—what we might also consider an awareness of circumstance and needs. The latter allow individuals to participate in resulting activities and develop new (or adapt/appropriate) language, signs and symbols (communication) to organize themselves and others in exploratory ways. This might also be referred to as the disposition to engage in “pretending” (Gee, 1992).

### **Collaboration/Communication/Competence**

In addition to the discussion of collaboration and communication discussed early on, Bandura’s (2001) model of agency offers a way to take the above characterizations into consideration and describe them in a developing comprehensive theory. This theory articulates a model of agency composed of four key components, which account for cognitive, affective and psychosocial characteristics: (1) intentionality, (2) forethought, (3) self-regulation and (4) self-efficacy. In this light, agency becomes a larger and more inclusive construct involving cognitive competencies included in forethought and self-regulation, e.g., selecting, planning, reasoning, monitoring progress, reflecting. In productive collaborations these four characteristics produce emergent collective actions and artifacts that describe truly jointly shared enterprises as individuals take up mutual

responsibility and accountability<sup>2</sup> for the activity and its product (Charles & Kolodner, submitted). In this fashion, self-regulation and self-efficacy are more than cognitive acts and become socially and culturally driven ones as well. In fact, Bandura claims that self-efficacy promotes a “pro-social” orientation. This is consistent with Holland (1998) and her colleagues’ thoughts on caring.

## **Positioning**

A final theoretical notion that needs to be briefly discussed is the notion of positioning. Positioning theory is a major shift away from the traditional role theories in sociology and psychology. It is a theory that comes from a social constructionist perspective and is very much in concert with the ways we have been trying to think about the dialectic tensions among structure/culture/agency. The notion of positioning suggests that the social positions that individuals take up are themselves produced within the social context and not fixed in advance from outside (Davies & Harré, 1990; Langenhove & Harré, 1999). From the position on “up takes” in a conversation, to the positions one has in an organization, to larger positions like social class, positioning theory focuses on the ways in which these positions are socially produced and on the dynamics of their characterizations. While radical social constructionism might suggest there is no larger structure and that all social relations are completely fluid, we would not embrace such extremes of position. We would argue that indeed some social positions that actors hold are more imposed, stable and difficult to struggle against. Further, we would argue that power relations in society are such that individuals can be positioned against their will, and that it becomes very difficult for them to resist that positioning. Often resistance is one of the ways that a subordinate position is maintained. The notion of positioning has a lot in common with the ideas of structure, culture and agency; it is an alternative way to talk about these issues.

What is important about bringing positioning into this conversation is that it is a dynamic way of seeing the micro-level of the structure/agency coupling being worked out. In the VMT chats we do not have data on students’ socio-economic backgrounds or the schools they attend. This data might be interesting to capture for future research, but it is not data that was part of the original project. So the larger levels of structure are a bit more difficult for us to comment on. But what we can see in the VMT chats clearly is that the interactions that students engage in are very dynamic. In contrast to some of the thinking in role theory, roles that students find themselves in either by being positioned by others or by their own efforts shift over the course of even a single work session (Harré & Moghaddam, 2003). Sometimes these shifts in position are related to insights the group makes, and so positioning is part of the process of group cognition. Sometimes shifts in position or the ways students find themselves positioned by others detracts from the group’s ability to

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<sup>2</sup> This mutual sharing of responsibility and accountability might be a social form of sharing in the *cognitive load* (Sweller, van Merriënboer & Paas, 1998) required to perform cognitive tasks such as problem solving.

make progress. So understanding the process of this micro-level positioning is an important part of understanding group and individual forms of agency—and how they are inextricably intertwined.

Greeno (2006) distinguishes different types of positioning. He talks about systemic and semantic positioning. While systemic positioning refers to what might be traditional views on the topic as discussed above, semantic positioning as a construct is more cognitive in nature. It refers to the sensitivities and awareness, the choices and judgments (attending, selecting, monitoring) involved in making collective meaning, and possibly also the creative activities that emerge out of collaboration and group problem solving.

## **Summary**

Taking all these theoretical ideas into consideration, we will now move to the analysis of VMT data in an effort to show some of the creative moments of agency and how the VMT system creates an opening for students who are constrained by the norms of classroom mathematics to really open up, think about and practice mathematics in new ways. But before doing so let us take a moment to summarize the key points in our proposition.

Agency is a product of human interaction in dealing with structural constraints. In this regard, there is a creative dimension to human agency, responsible for the production of new structures and the emergence of cultural change. This creativity may be brought about through mechanisms of improvisation and imagination, allowing for flexible social positioning and malleable sense of identity. In collaborative activities these help to develop competence to communicate and engage in discursive processes, which are paramount to knowledge-building processes, e.g., presenting ideas, building connections and refining shared artifacts (including language and meaning).

We believe it is reasonable to suggest that the notion of agency can be applied to understand learning in the socially charged context of CSCL, i.e., the creation of personal and group meanings, shared knowledge and joint ideas. In doing so, learners may break away from the structural constraints of well-worn thoughts and old habits of mind—thoughts and habits that might include traditional ideas about learning itself (i.e., teacher-lead learning), or collaboration itself, (i.e., social positioning when working with others). New environments provide new opportunities for agency because of the liberation of these old constraints and the creation of new ones.

Further, we would argue that the binary opposition between individual and group or public and private are largely false distinctions. In the Western tradition, we have had a tendency to think about cognition as primarily something that goes on in an individual's head as a private set of mental processes. Once those private processes have gone on—essentially independent of the social context—to form ideas, internal representations or mental models, the ideas may then be externalized, articulated, communicated and shared with the group or made public. But this view of cognition and communication is naïve and does not really reflect the way knowledge is



developed or understood. While we do see individuals as critical to this process, we do not see a sharp separation between individual and group.

As Peirce said, all thought is dialogic. By that he meant that every private thought was the product of some former interaction and had an interlocutor in mind. Human thought is by necessity collective. The moves of particular individuals—and the strengths or weaknesses they bring to an interaction as individual participants—help form the interaction, the way knowledge is produced, the discoveries the group makes and the limitations they encounter. There is really no way to talk about individual cognition separate from group cognition. This is one piece of what Sfard (2008) implies with her notion of “commognition”—that cognition and communication cannot be separated.

## **VMT Data Analysis**

### **The Research Setting**

Before moving forward, we briefly describe the assigned tasks the students focused on during the featured segments. The data for this chapter comes from VMT Spring Fest 2006 (also partially analyzed in Chapters 7, 8, 10, 26). VMT Spring Fests were competition where teams of students worked online to discuss a set of challenging, open-ended mathematical topics. The “grid world” topic for 2005 is shown in Figure 6-2 and the “stick patterns” topic for 2006 is shown in Figure 7-1. The team judged the most collaborative in 2006 was awarded iPods. So while the students involved seem very interested in math problem solving they also have an external incentive.

We selected Team B because of their attendance record, which allowed us to better track the progress due to individuals’ agency, or lack therefore. They had four one-hour sessions working with and getting to know each other over two weeks. The full transcripts of these conversations are very long; here we look at just a couple of moments.

The teams were formed online and in general the students did not know each other or have contact with each other outside of the VMT sessions. The VMT Project is designed so that factors that are not visible in the chat room do not influence the interaction or the analysis of its record. Neither participants nor researchers know the students’ real names, geographic location, gender, age, ethnicity, appearance, socio-economic status, speech accent, personality, habits, etc. In some cases, students came from the same school. According to evidence in the transcript, two students in Team B, Aznx and Quicksilver, knew each other from school; the third student, Bwang, lived in a different part of the US. From their real names, which were used occasionally in the transcript, we infer that all three are male. Because they were recruited by certain teachers, we know that they are approximately 12-14 years old. There is no evidence that they communicated about the chats outside of the environment.

In this analysis we approached the data from more of a discourse analysis perspective than a traditional conversation analysis one. While both forms of analysis look closely at text and the meanings produced therein, discourse analysis concerns itself with larger social forces such as the discursive construction of race and gender and hence may look across a wider range of utterances in a single moment of analysis. This allowed us to start with a larger chunk of the data and to develop a sense of the overall instances of agency in order to determine whether there was indeed evidence of creativity, collaboration and competence. We then identified the specific data snippets we are about to look at.

### An Early Example of Agency

To start we look at Log 11-1, an excerpt from the beginning of the transcripts of Team B's first session. In establishing the structure of their working together to solve an open-ended math problem they demonstrate certain social actions, which we describe as early examples of agency; these seem to contribute to the success of their collaboration.

*Log 11-1.*

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58	06.33.05	bwang8	so you can see we only need to figur one out to get the total stick
59	06.33.09	Aznx	read the problem
60	06.33.32	bwang8	1+2+3+.....+N+N
61	06.33.38	bwang8	times that by 2
62	06.33.40	Quicksilver	Never mind I figured it out..
63	06.34.01	Aznx	Can we collaborate this answer even more?
64	06.34.05	Aznx	To make it even simpler?
65	06.34.15	bwang8	ok
66	06.34.16	Aznx	Because I think we can.
67	06.34.50	bwang8	$((1+N)*N/2+N)*2$
68	06.34.58	bwang8	that's the formula, right?
69	06.35.15	Aznx	How did you come up with it?
70	06.35.16	bwang8	for total sticks
71	06.35.34	bwang8	is a common formual
72	06.35.40	bwang8	formula
73	06.35.46	Aznx	Yeah, I know.
74	06.35.59	bwang8	and just slightly modify it to get this
75	06.36.31	Aznx	Aditya, you get this right?

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Line 63, “Can we collaborate this answer even more?” is an agentic move because it slows down Bwang, who up to that point is acting unilaterally and moving ahead with the problem-solving task without consulting the others (line 58, 60, 61). It takes a certain initiative to stop the flow of ongoing action and steer it toward another course. Additionally, the comment positions collaboration as a goal in the communication, and may be responsible for the spirit of collaboration we see emerging. Aznx’ posting should probably be seen as taking up the moderator’s earlier reminder: “remember, you are trying to collaborate” (occurring in line 38 of the transcript).

In line 65, Bwang accepts Aznx' proposal, "ok", allowing the team to change course and begin to build a social structure framed on collaboration as a goal. This goal is confirmed in line 66, Aznx's statement—"Because I think we can"—which can be seen as a declaration of distributed capabilities. Alternatively, it can be viewed as a statement of the group's authority to take autonomous action. Either way, Aznx' statements demonstrate he is taking on a sense of responsibility for the goals set by Team B.

The follow up response, line 69, again displays a willingness by Aznx to take action. This comment helps build the group's common ground by asking Bwang to share his knowledge. At this early stage there is no negotiation of meaning as we see in the comment, "(it) is a common formula" (line 71), which is followed by "Yeah, I know" (line 73). In line 74, however, Bwang positions this knowledge as something malleable. In doing so, he opens it to possible future negotiation. This positioning of the concept is an agentic move because it expands the common ground and who is allowed to contribute.

Constructing and defining the rules of operation (i.e., the practices) for working together calls for a certain agency on the part of some, or all, individuals involved. The initial structure of this particular VMT chat environment emerges out of the ways these three students choose to respond to each other, their awareness of the circumstances (or lack thereof), and perhaps even the roles that they were willing to take on. In doing so, agency uses the mechanisms of positioning (Greeno, 2006)—both systemic positioning (roles and importance of the agents and resources within the system, e.g., Aznx positions collaboration and explanation as more important than individual problem solving) and semantic positioning (meanings and significance of the practices and concepts used by the agents, e.g., Bwang positions the historic formula as malleable by the students).

### **Later Types of Agency**

Before moving forward on this task let us take a moment to consider some important factors relating to how agency is exhibited. At one level we could say that the students in Team B took responsibility for their own learning and their developing competencies—i.e., setting goals, planning their actions, selecting cognitive strategies, monitoring and evaluating their progress in autonomous ways. As stated above they did this as both individuals and as a group. Their individual action is completely tied up with their interaction with each other such that their cognitive moves are communicative moves as well, as shown in the earlier vignette. In doing so, this team could be said to have expressed their agency and demonstrated an educationally productive use of their agency. However, what is considered agentic actions changes over time.

If we are to better understand agency and appreciate the complexity of this type of social action we also need to view agency along a continuum of significance (or consequences) of actions—small-scale to large-scale. Assessing the significance of actions, however, is dependent on context (what is the structure of the environment, its rules and its resources) and history (who participated in the action; what is the

temporal nature of the structure, i.e., ongoing or time-constrained). In other words, given that all social action is situated, interpretation of such action must take into account the dimensions of context and history. Our first vignette tried to show how actions at the start-up of a group working together (time-constrained social action) might be small in scale but are nonetheless agentic because of the nature of establishing and negotiating the system's structure. Meanwhile, later actions (the upcoming vignettes) show a different type of agency (based more on creativity and competence) because of a re-constitution of established structural forces.

### **A Three Part Example of Agentic Movement**

Below we have divided an extended set of interactions into three log segments. These are from near the end of the last of Team B's four sessions. At this point the participants' various competencies have developed significantly. When we began this analysis we tended to see Bwang as the "math student" because Bwang was very good at taking a given problem and expressing it in an equation. He had a certain math orientation and was often the first to create mathematical objects that the group later worked with. Aznx was very skilled at being creative in thinking about new problems and facilitating interaction, caring about the group as we saw above. Quicksilver was harder to get a sense of. But as we move into this final phase of work we see some significant re-positioning as each of the students engages in new forms of presentation of themselves, and there are new ways in which they react to each other. Further, much of the interaction up to this point has been an example of the kind of social action we discussed at the beginning of the chapter, where the action proceeds down a pretty clear channel and there is little disruption of the structure and the flow of action. But in this passage (Log 11-2) we will see a more significant form of agency where the "normal path" melts away in the realizations of the actors.

*Log 11-2.*

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1512	07.43.22	Aznx	what in the world?
1513	07.43.26	Aznx	am i going crazy?
1514	07.43.26	bwang8	don't consider the 4 corners
1515	07.43.29	Aznx	someone check my work.
1516	07.43.36	Aznx	simplify their formula
1517	07.43.51	Quicksilver	k
1518	07.43.55	bwang8	what do you mean
1519	07.44.30	Aznx	$2(n^2+n^2-2n+1)+3n-2$
1520	07.44.34	bwang8	i don't see how you can simplify it
1521	07.44.35	Aznx	simply the formula
1522	07.44.40	Aznx	for the number of sticks
1523	07.44.45	Aznx	so that simplifies to...
1524	07.45.45	Aznx	I stil get the same.
1525	07.46.20	bwang8	how did you simplify it
1526	07.46.27	Aznx	um
1527	07.46.32	Aznx	square the n-1
1528	07.46.39	Aznx	then multiply the whole thing by 2
1529	07.46.47	Aznx	then multiply the 3 and n

1530	07.46.51	Aznx	and add it with that
1531	07.46.57	Aznx	and subtract by 2
1532	07.47.14	bwang8	quicksilver
1533	07.47.19	Quicksilver	im lost
1534	07.47.23	bwang8	did you get the same answer
1535	07.47.30	Quicksilver	no
1536	07.47.39	Aznx	i'll do it on the board
1537	07.47.44	Quicksilver	yeah
1538	07.47.53	Quicksilver	i got something totally difrent
1539	07.48.36	bwang8	so far i got $4n^2+3n$
1540	07.48.55	Quicksilver	indranil rite in the box
1541	07.49.17	bwang8	i mean $4n^2-n$
1542	07.49.26	Aznx	EXactly

In lines 1512 and 1513 of Log 11-2, Aznx begins this new path through an exclamation. The “**what in the world**” and “**am I going crazy**” are utterances that reorient the participants and the reader of the transcript. Aznx sees something really big. At first it seems as if Bwang does not see the drama and suggests that Aznx not consider the corners in his analysis of the number of sticks in the shape. But quickly he sees that Aznx is concerned about something bigger. When Aznx positions himself as the leader of a new route of inquiry and positions the others as helpers in that task, Quicksilver takes up the positioning and agrees to check Aznx’s work. But Bwang is more confused. He resists and also requests more information as he says, “**I don’t see how you can simplify it.**” This statement opens an opportunity for Aznx not only to continue to be a leader in this interaction but also to demonstrate his math competence. We have not often seen Aznx talking about math in this whole session, but here he initiates a series of teaching moves, showing Bwang and Quicksilver how he reduced the formula of Team C. In lines 1527 to lines 1531 Aznx skillfully shows the other two how to reduce the formula. This work looks like the role that Bwang often takes in leading the math interaction. Quicksilver seems initially to have a little trouble with this work as he is coming up with a different result, but Bwang gets what Aznx got,  $4n^2-n$ , to which Aznx responds, “**Exactly.**” That final response is filled with meaning as he is expecting Bwang to see something significant in that equation. It is one that they as a group earlier had proved was wrong.

The fact that the three students in Team B change roles quite dramatically was discussed in Chapter 10 from a quite different perspective. Here, we see the participants position themselves and each other interactionally to take on the roles of math explorer, explainer, questioner, checker, etc. This is a matter of individual agency within the problem-solving agency of the group. In Chapter 10, it was argued that the group developed social practices—patterns of activity that became established habits of behavior that over time became accepted and understood within the group. In this chapter’s terms, these emergent practices were examples of Giddensian structuration and Bourdieuan habitus. Chapter 10’s analysis of the Team B transcript (including the whiteboard inscriptions, or Latourian mobile immobiles) showed that the three students each took a turn initiating the team use of their social practices, demonstrating the extent to which these practices had truly become shared

practices. Certainly within mathematics, in order to demonstrate that one has learned a skill and is competent in it, one must be able to apply the practice under appropriate circumstances in a way that is recognizable as that practice. In Log 11-2, Aznx is demonstrating his competence, which has been questionable for some time. This is a strong agentic move by him as an individual, and it drives the agency of the team toward its discovery vis a vis Team C's work.

The conversation in Log 11-2 is interesting at a number of levels. One of the things that Team B had been told they might do by the moderator feedback after their last session was to look at Team C's solution to the diamond pattern and perhaps to work on a 3-D version of that problem. Out of that open set of instructions about what the team might do, the students may have made some normative assumptions that Team C's equations were correct, since they had been encouraged to look at them. Included in that set of assumptions were some assumptions about the role of teachers and mentors and how normal classroom activity would go. Why would a teacher (or in this case a surrogate teacher) ask you to look at someone's work if it was wrong? But in this section of the discussion Aznx has begun to show a mathematical skill he has, reducing equations, and he even takes the opportunity to teach Bwang, who up until this point has been the lead math person. In their reduction of Team C's equation they discover that it is wrong. Team C's equation simplifies to  $4n^2 - n$ . But in their own work they had earlier arrived at this same equation and realized themselves that it did not work. Now they are realizing—thanks to Aznx's lead—that Team C was wrong too. In this interaction we see Aznx taking the lead. Quicksilver seems to be having a little trouble following, but he will catch up with the rest of the group. In this section each of the students finds themselves re-positioned by each other and by the context. This creates a level of excitement that we have not seen so far in the chat.

In this next section of the conversation in Log 11-3 the students react to their amazing discovery.

*Log 11-3.*

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1543	07.49.40	Quicksilver	yea that waht azn x got eralier
1544	07.50.00	bwang8	holy
1545	07.50.03	bwang8	moley
1546	07.50.05	Quicksilver	whyd u multiply by the two
1547	07.50.13	bwang8	i think their equation was wrong
1548	07.50.15	Aznx	It's in the equation
1549	07.50.19	Quicksilver	oh
1550	07.50.20	Aznx	Whoa dang
1551	07.50.25	Quicksilver	i missed that then
1552	07.50.25	Aznx	their equation is wrong!
1553	07.50.27	Aznx	lol
1554	07.50.28	Quicksilver	thats why i was off
1555	07.50.36	Aznx	and concidentally, that's what i got
1556	07.50.37	bwang8	because the simplified one wouldn't solve the
			problem
1557	07.50.41	Aznx	i was thinking about the sides
1558	07.50.48	bwang8	why don't we use it on some other level

1559	07.50.52	Aznx	and thought there had to be 4n somewhere in the scenario
1560	07.50.56	bwang8	see if it works
1561	07.50.57	Quicksilver	lol
1562	07.51.00	Aznx	it doesnt
1563	07.51.01	Quicksilver	never assume
1564	07.51.05	Aznx	it doesnt work

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One of the reasons Aznx and the rest of the group knows the simplified equation is wrong is that Aznx tried to use it earlier in the session and the group saw that the equation did not work. Here they are each in their different ways coming to a realization about the implications of Team C's equation being wrong, as there is a kind of group "commognition" reorientation, to use Sfard's term.

While Aznx had the shocking realization in the earlier section, here Bwang is only beginning to see the repercussions of the moves that Aznx made before. And in an amusing way that both reinforces Aznx's earlier excitement and expresses his own awe, Bwang divides his "holy moley" between two lines—perhaps to emphasize the power...holy...moley—and then he says in 1547 "I think their equation was wrong." Aznx allows Bwang to speak for the group here by announcing in words what Aznx has already demonstrated he knows indirectly through expressions of affect and surprise. In the meantime Quicksilver is still a little slow to follow and in line 1546 asks "whyd u multiply by the two." Aznx both positions himself to help Quicksilver and then immediately follows Bwang up on his voicing the realization by stating in line 1552, "their equation is wrong!" The students then very collaboratively think through how they got to where they are now and also realize that the equation does not work at all.

In the last section of the conversation in Log 11-4, we will see the students attempt to engage the moderator of the session (Gerry). In these sessions the moderator is really only supposed to answer technical questions and not instruct or engage in the mathematics.

*Log 11-4.*

1578	07.52.29	Aznx	Gerry?
1579	07.52.30	bwang8	let's find out the real solution
1580	07.52.34	Quicksilver	yeah
1581	07.52.40	Gerry	What?
1582	07.52.48	Aznx	Their thing doesn't work.
1583	07.52.56	Aznx	We tried it.
1584	07.53.18	Gerry	I know you tried it. I saw.
1585	07.53.24	Quicksilver	lol
1586	07.53.32	Quicksilver	anyway
1587	07.53.32	Gerry	It does not even work for one square
1588	07.53.33	Aznx	So what do you think?
1589	07.53.40	Quicksilver	lets find the real answer
1590	07.53.43	Aznx	So their solution was wrong right?
1591	07.53.49	Aznx	Yeah, let's find it out.
1592	07.53.57	Aznx	But I want to make sure thgat it was wrong.
1593	07.53.59	Gerry	looks that way, doesn't it?
1594	07.54.07	Aznx	Yeah it does.

---

Here Aznx cannot quite believe their discovery. Bwang and Quicksilver are ready to move on and find the correct solution to the problem inspired by their discovery. But Aznx has to ask Gerry twice if they have really found something significant here. Gerry attempts to continue the low-key role of the moderator, but indirectly corroborates the group's finding in line 1593. Aznx's reply to him is appropriately subtle. Specifically in lines 1582 and 1583 Aznx shares their experience with Gerry by stating, "**Their thing doesn't work**" and "**We tried it.**" The moderator indicates that he is aware of what they have been doing, which could be read as a tacit acceptance of their results. But moderation has been very low key in these chats and so it is not clear that Gerry has supported their work. While both Bwang and Quicksilver call for finding the real solution—attempts to reposition the activity of the group—Aznx continues to resist as he seeks greater corroboration. In line 1590 Aznx directly positions Gerry as the authority by asking, "**So their solution was wrong right?**" Then to his fellow group members in 1592 Aznx makes his pursuit of Gerry very clear by saying he wants to make sure that it was wrong. It is interesting that while Bwang and Quicksilver are ready to move on, Aznx wants the voice of authority to validate their discovery. As a non-interventionist moderator, Gerry both gives Aznx what he is looking for and resists being positioned as the authority as he says in line 1593, "**looks that way, doesn't it?**" To this, Aznx replies in the same fashion in 1594, "**Yeah it does.**" We can see in Gerry's posts the effort of the moderator to have minimal impact on the way the group thinks about what they are doing as well as on how they do what they are doing. His positioning work can be seen as an effort to keep the focus on the team, positioning the team to continue to be the agent of problem solving, checking and confirming.

## Discussion

Clearly, the unique features of the online chat and whiteboard tools influence the patterns of practices engaged in by the social actors in VMT, thus implicating the structure emerging from this social setting. In this case the structures produced through the interactions of the students involved act to negotiate and co-regulate the production of meaning, the norms and values of the jointly created figured world, as well as the exercise of power—what Giddens (1979) refers to as signification, legitimation and domination, respectively.

Traditionally, the structure of the classroom and the agency expressed by that structure, are transposed from other similar settings. Thus the constraints of past experiences may significantly limit what actions students take. Face-to-face classrooms can limit student expression along two major lines: First, existing structural asymmetries come to the fore such as gender, racial and class inequality. Classrooms must struggle to overcome these inequities as they are worked out in the interactions in class; as we know from the literature in education, they often fail to do so. According to Cobb and his colleagues (2000), past interactions in classrooms often form core identities where students do not feel they are good at math and they



struggle against those identities that they have of themselves and the ways their identities are shared with others.

In the relatively new online chat environments, however, such structures, if they exist, are borrowed from purely social experiences (e.g., in socializing chat rooms and personal-opinion blogs). Thus in many cases the signification and legitimation are newly developing practices, and domination may not play a central role—at least not initially. Furthermore, with malleable structures there are malleable constraints, which offer greater opportunities for improvisation—the creative and unexpected taking of dialogic turns. When we think of how these adaptive structures relate to agency in collaborative activity, we see collaborative group learning in a different light.

In the examples we've given, we show that learning can be described as creative and improvised acts of agency—both individual and collective. VMT's online chat and whiteboard environment appear to free the students from the other kinds of social constraints that exist in their worlds and give them opportunities to make creative problem-solving decisions. It may also be that the types of students who are drawn to these settings are those who are more familiar and comfortable with these newer social constraints. In our example, the math topic is one that asks students to think about the relationship between the numbers of sticks one uses to make a pattern of squares and then what happens when one puts those squares into different shapes. This is a very open-ended kind of problem that might be intimidating in a typical classroom setting. But in the VMT chat the students creatively play off of one another in order to gain shared insights about the sticks and squares problem. They are able to take up a sense of agency as they play with the problem and help to define new questions to ask.

Agency requires individual and collective actions. When individuals begin to interact in coordinated or shared contexts, interdependencies are characterized by the development of mutual accountability and co-regulation—socially negotiated responsibilities, expectations and standards from which everyone is evaluated, including oneself. Interconnectedness is characterized as the development of mutual benefit—awareness of distributed capabilities, i.e., that everyone may benefit from the individual's attending and selecting, reasoning and reflections—and by the awareness of the development of a shared culture, resources and social history—ways of questioning, mathematizing and producing solutions.

In the brief examples shown, we see the interplay between individual and group. The VMT chat is a space that in some senses is liberated from the social constraints of a physical space. With virtual bodies and minds (or voices, see Chapter 24 on the interplay of polyphonic voices in VMT) students have the opportunity to play off of each other and to enjoy the creativity of that play (see Chapter 12 on group creativity in VMT). This potential for an open and free interaction encourages individuals to be agentic, and thereby encourages the group to support the individuals and stimulates students to act like mathematicians, exploring together the math worlds they project.

VMT chats like Team B's sessions create something unique and promising: an online world where students can take control, define problems, respond to each other and then explore the problems of their own making. In this way they behave more

like mathematicians-in-training than like students being taught. This is not to argue that traditional forms of math instruction do not have their place as well in the future of math education or, indeed, that there is no role for adult educators. Clearly, the setting up of the math environment—topic, tools, resources—the moderation of the chats and the feedback between sessions can be seen in our data to be critical to the success of the student interactions. In addition, the positive experiences in the chats should ideally feed into integrative classroom processes before and after the chat, making connections across teams and integrating discoveries into the larger curricular picture. But the chat seems to open up a potentially transformative space in which student and small-group agency can be liberated. Within CSCL, Dillenbourg & Jermann (2006) have argued quite generally for scripting education with periods of collaboration where the student groups have full agency—bracketed by periods of teacher-led classroom activities and other periods of individual learning.

We would suggest that the VMT environment has the potential to overcome the structural constraints that one might see on social action from a Giddensian or Bourdieuan perspective. These constraints are to some extent avoided because the environment creates a collaborative space that can be defined by the participants and does not necessarily reproduce all the hierarchies or power relations in traditional school settings. Of course, it can also be argued that eventually a certain kind of social network will develop within the chat groups, based on their social interactions and potentially producing or reproducing hierarchies and power relationships. However, it is the creativity that VMT's constraints promote that is striking in our data.

The social action that is visible in the VMT data corpus shows student teams creating new structural realities for their further work together. As Giddens suggests there is a self-consciousness to this social action. The social action that is encouraged is creative and draws upon the participants' imaginations to see knowledge production as an enjoyable, stimulating activity that is accessible by ordinary people. Understanding how to harness this agentic behavior and to leverage it for scalable, sustainable learning will be a next step for this research.

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