Creativity, Collaboration and Competence: Agency in Online Synchronous Chat Environment

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Abstract: Agency is potentially an important concept for CSCL as researchers think about the effectiveness of online learning environments and the ways they encourage groups to take active control of their learning activities. This paper reports on several sessions of mathematics problem solving in the VMT Chat environment. The VMT Chat is a synchronous chat and whiteboard space for students to collaboratively define and work on problems that are open-ended and that encourage students to define the questions themselves. We draw on the anthropological, psychological and sociological traditions and their concept of agency in order to produce a robust analysis of several segments of student work in the VMT Chat. Our analysis suggests that there are structural features to the VMT Chat environment that encourage "agentic behavior" on the part of students. This has important implications for learning and the structure of pedagogic activities.

Introduction

This paper looks at the mathematics problem-solving behavior of students in the Math Forum's VMT-Chat environment. The VMT project is a project that is attempting to provide an online synchronous environment for small groups of students to work on math problems together. The project has not only designed a whiteboard/chat environment for students to work in but also does research on various aspects of online collaborative problem-solving.

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. 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 centre programs; and to online, face-to-face or to some blend of these. In all cases the one constant is the use of computer tools and artifacts to create activities for intellectual exploration and promotion of social interaction (Stahl, Koschmann & Suthers, in press). These activities are designed to engage students in learning through jointly negotiating and planning how to proceed, generating questions and exploring possible problem solutions together, in the process modeling and scaffolding learning for each other. In short, instruction and learning is viewed as a group initiative and not a teacher lead effort, hence, supporting and sustaining productive interaction is crucial. A major design consideration should be the promotion of students' *agency* over the processes by which knowledge and ideas are created and improved, sometimes referred to as *epistemic agency* (Scardamalia, 2002). In fact, Scardamalia and Bereiter (1994) describe the release of agency as a guiding principle in the design of their knowledge building communities (KBC). But what do we know about this phenomenon? How do we know that our computer supported learning environments are harnessing (marshalling) the potential of the powerhouse individual and group attribute? What does agency look like when we take a close view of the interactions between individuals? What can we learn from a close examination of this phenomenon that may help design future collaborative environments (both online and face-to-face) or may help promote the development of agency in less agentic groups?

In this paper we use the concept of agency to frame our analysis of some recent data in the VMT-Chat environment. We are interested in thinking about agency as a concept because we would argue that students and groups with a greater sense of competence and self-efficacy will have the potential to make greater progress in their mathematical learning. Agency as a concept helps us understand the relationship between structural (including technological) constraints and human action. This in turn can inform our thinking about the strengths and weaknesses of this kind of online project for a sense of identity, competence and self-efficacy.

The Research Setting

Virtual Math Teams (VMT) is a five-year NSF funded project starting in Fall 2003 designed and run by researchers at Drexel University and *The Math Forum* (http://mathforum.org). Its aim is to create an online environment to promote and support the knowledge building and math discourse between groups of individuals who enjoy doing math but do not generally have opportunities to meet and work with like-minded learners. To achieve these goals, VMT researchers designed a software environment called *VMT-Chat*, which provides chat rooms for small groups to meet on the Web to communicate about math and engage in joint problem solving, mediated by a whiteboard, chat logs and associated referencing pointing tools all archived for future referrals. By bringing learners together, the VMT environment and tools challenge participants to engage in collaborative activities that call for jointly negotiating goals, meaning of the shared tasks while constructing problem solutions (e.g., explaining and defending own ideas) and jointly regulating the group's progress.

Structure/Agency

Before we start let us briefly situate agency within the CSCL literature. Most notably, the notion of agency, specifically epistemic agency, has been the focus of work conducted by Marlene Scardamalia and her colleagues (e.g., Scardamalia & Bereiter, 1991; Scardamalia, 2000; 2002). 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 negotiate a fit between personal knowledge and those of others "using contrasts to spark and sustain knowledge advancement rather than depending on others to chart that course for them." (e.g., Halewood, Reeve, & Scardamalia, 2005, p.2). In taking on the responsibility for aspects of learning, such as, goal setting, motivation, evaluation, and long-range planning, students demonstrate their epistemic agency. As such, 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 a member of a community, hence their community identity. Which, along with epistemic agency is seen as mutually constituting the students engagement in community discourse (Brett, 2002). We will return to this line of reasoning below.

As a particular case of the larger Western pre-occupation with determinism verses free will, sociology and the social sciences since their inception have tried to think through the relationship between structure and agency. One interesting perspective on the structure/agency binary is the thought of the British sociologist Anthony Giddens. For Giddens structure is a product of the pattern of practices that social actors engage in. Therefore structure is emergent out of human activity. Further there are different levels of structure that emerge out of different forms of human practice, signification, legitimation and domination. Signification has to do with the production of meaning, legitimation the production of moral order through norms and values and domination of course is produced through the exercise of power (Giddens, 1979; 1984).

These above types of structures are produced by human activity but once they exist they then work to constrain future human action. Therefore the structure produces patterns of activity that, in the French sociologist Pierre Bourdieu's terms, becomes habitual action structured through activity of the past but then used to structure and classify future activity as well as things in the world. This dialectic used by both Bourdieu and Giddens is one way to overcome the primacy of either structure or agency and succeeds 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 that 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).

Giddens and Bourdieu's understand of the relationship between structure and agency is very useful for our analysis of the VMT. From the beginning the VMT project has been a design-based development project. And so the practices of students using earlier generations of the chat environment (even starting with just AOL IM) influenced design decisions for future environments. The goal of the design team has been to enable future activity that the participant sought to engage in and to constrain activity that seemed to detract from the productive working together of the problem-solving teams. But further the activity of the participants themselves solving a problem and interacting with the technology begins to build up a kind of small group structure that 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 the team work.

Creativity/Imagination/Identity

In a major article on agency, Emirbayer and Mische (1998) offer a critique of the Giddensian and Bourdieuian 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 on the one hand and Emirbayer and Mische on the other represents a very important 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 one 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 theorist tend to emphasize one pole or the other.

Our hope 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. We would argue that much of social life is constrained structures that themselves are the product of past action both conscious and habitual and that these constraints are something that social actors must indeed face. But on the other hand as we will discuss below there are creative potential for social actors to engage with those structures in new ways. We feel that online services like the one the VMT is constructing in fact facilitate the creative and imaginative when students attempt to deal with the constraints around learning math.

Emirbayer and Mische want to emphasize the creative dimensions of human agency. For them these dimension have a future focus and are tied up with creativity, imagination, improvisation etc. This notion of identity dovetails nicely with the work of Bandura (2001) and Dorothy Holland and her colleagues (Holland et al., 1998).

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 psycho-social characteristics: (1) intentionality, (2) forethought, (3) self-regulation, and (4) self-efficacy. Agency is more than a mere self-regulating activity, rather it is involves planning, reasoning, monitoring progress, and reflecting on beliefs about one's capabilities. Viewed in this light, agency can be both a quality of actions produced by an individual as well as the interactions produced by a group of individuals. In other words, when working collaboratively as a group, these four characteristics can be transposed into jointly shared actions or enterprise. As a collective production, intentionality is jointly negotiated, forethought is jointly shared, members engage in co-regulation of progress, and the group develops a sense of co-efficacy or belief in a collective capability (Charles & Kolodner, submitted). In this manner self-regulation and self-efficacy become more than cognitive acts, but social and culturally driven ones as well, in fact, Bandura claims that self-efficacy promotes a "prosocial" orientation. Taken as a whole, these collective productions implicate changes to identity – possibly shifts from individual identity to group identity (i.e., team member or even member of larger discipline-specific member).

According to Holland et al. (1998), agency is intimately related to, and 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" (Holland, et al., 1998, p. 5). Thus agency and identity are mutually constitutive systems that play out in two forms: (1) acts of improvisation; and, (2) acts of self-directed symbolization. Improvisations are actions that are independent of structural or cultural constraints. They are mediated by one's "sense and sensitivities," what we might also describe as awareness of perceived need to act. Symbolization refers to the human ability to create imaginary worlds, "*figured worlds.*" It allows learners to participate in activities and use language, signs and symbols, to organize themselves and others in exploratory ways. What Gee (1992) refer to as the disposition to engage in "pretending."

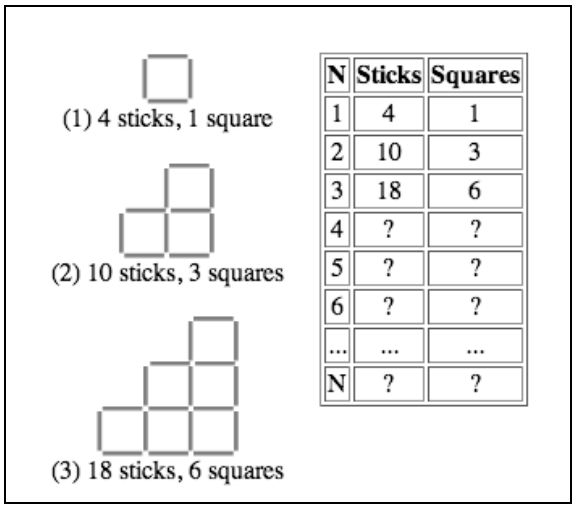
Taking all these theoretical ideas into consideration, we will now move to the analysis of VMT data in an effort to show some of the creative moments of agency and how the VMT system creates an opening for students who are constrained by the norms of classroom mathematics to really open up and think about and practice mathematics in new ways.

VMT Data Analysis

The data snippets that we are about to look at are part of a set of conversations that a group of four students[1] engaged in around a series of open-ended problems. Six other similarly composed groups participated in this pilot study. We selected this group because of their attendance record, which allowed us to better track the progress due to individuals' agency, or lack therefore. The students meet for the first time in the chat environment, thus had no prior histories together. They had four one-hour sessions working with and getting to know each other over several weeks. The full transcripts of these conversations are very long. Here we look at just a couple of moments in this much bigger problem solving activity. Before moving forward, we briefly describe the assigned tasks the students focused on during the featured segments.

The Assigned Tasks

The "stick" challenge starts with an identification of pattern and construction of mathematical rules to describe the growth of a graphical pattern. For example, in the first session, students are provided with the representation below (see Figure 1) and asked to account for the growth in numbers of sticks used and squares created when N=4, N=5, and so on. In the second session, which we discuss, the students continue to work on this problem, but this time they are asked to extend their reasoning to include creative problem solving such as constructing other mathematical problem related to the problem with the sticks. For instance, they are asked to consider other arrangements such as triangles, hexagons, 3-D figures, like cubes with edges. As well, they are asked to analyze their patterns using different methods such as induction, recursion, graphing, tables, and so on.



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

Figure 1 – Example of the initial sticks task.

A typical example of what the whiteboard looks like at the end of session 1, and the beginning of session 2 is below (see Figure 2). From this point, students negotiate the meaning of concepts such as recursion, coordinate drawings of graphical representations and jointly construct mathematical formulas to account for the patterns they identify. (NB. the formula on the whiteboard is ((1+N)*N/2 + n)*2).

[1] Due to the design of the study, the participants were anonymous therefore we do not have exact ages for the individual students but they were approximately 12-14 years old. This design also ensured that the students had no prior history together.

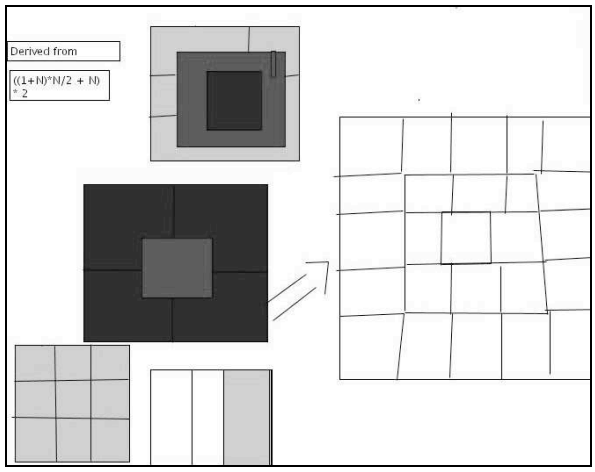


Figure 2 – Segment of Team B's whiteboard, Session 2

The grid world challenge starts off with a situations where the students are asked to imagine they live in a world where one can only travel along the lines of a grid - for example, driving in a city like Manhattan or Philadelphia. They are asked to construct solutions for the shortest path between two points, A and B, remembering to stay along the grid. The are then asked to extend this reasoning by creating relationships between points when A is at (x1, y1) and B is at (x2, y2). For instance, a solution used by Team 5 in their fourth session (see Figure 3). Such problems encourage students to define and calculate grid distances, define analogs to shapes defined in Euclidean geometry. In doing so, students engage in reasoning with mathematics as a creative enterprise.

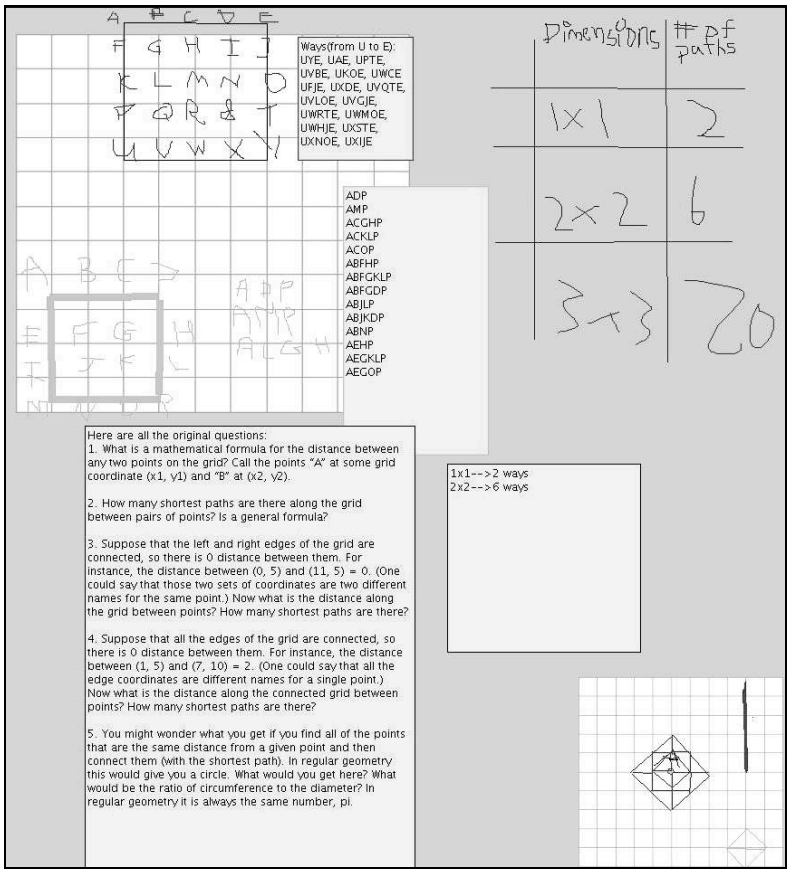


Figure 3 – Snapshot of grid world whiteboard.

Case Studies

We believe that synchronous online chat environments, designed specifically to engage participants in learning, are special in that they require individuals to take on certain kinds of agency, which may have implications on how and why they learn. This agency is demonstrated in a variety of ways, most noticeably in student's self-efficacy, in their intentionality related to negotiation of the goals to be achieved, and in their co-regulation of the progress of activities leading to the attainment of those goals.

This is different from traditional classroom learning (and perhaps other forms of online learning such as teacher lead e-learning), and even perhaps what we generally see in face-to-face small group problem solving because of the unique features of the environment. These features include purposeful equalizing of positional identities (true sharing of authority because of the anonymity of participants – histories are developed within this setting), the linear nature of the conversation (only one voice at a time), the "engraved" nature of time (conversations and artifacts are archived and retrievable), and the cultural practices that are necessitated or made possible by the technological tools (e.g., pointing back with the referencing tool; waiting to respond until after reading a posting). We propose that to function within these structures may require or encourage/promote a certain sense of agency.

Take the following excerpt as an example. It is the second of 4 sessions with three students (Quicksilver and bwang8 and Aznx) working on a math problem involving sticks. In the beginning it is clear that Quicksilver and bwang8 are capable of working together to find the solution to the problem presented. They engage in small linear acts of building on the others ideas or questions, each time reflecting an interplay of planning the next step (intentionality) and regulating how it fits the intended goal (i.e., solve the problem). What comes out of these small linear actions is a sense of shared achievement and moving forward. For others, such as Aznx, however, it appears that their sense of agency may be related to time to reflect on the archival structures of the environment.

591	Quicksilver	08.04.03:	you guys can add on
592	Quicksilver	08.04.08:	i just put the basic
593	Quicksilver	08.04.20:	Maybe share our results?
594	Aznx	08.04.53:	We technically had the same result.
595	Quicksilver	08.05.07:	Whaddya mean?
596	Quicksilver	08.05.21:	oh as yesterday?
597	Aznx	08.05.31:	Yeah.
598	Aznx	08.05.36:	And today.
599	Quicksilver	08.05.40:	Still...
600	Aznx	08.05.43:	Well today was really a discussion.
601	Quicksilver	08.05.46:	we should say that'

His general contribution to the group changes significantly once he positions himself as someone who makes observations such as the one above and has capabilities the group will need (i.e., he is good with words). In this occasion he expresses a high degree of self-efficacy and takes on an active role in constructing the artifact to be posted on the group's wiki.

609	Aznx	08.06.55:	Wait, who is submitting?
610	Aznx	08.06.57:	bwang?
611	bwang8	08.06.59:	tell them the intervals between levels

612	Aznx	08.07.06:	or quicksilver, or me?
613	bwang8	08.07.08:	sorry, i am bad with words
614	Quicksilver	08.07.14:	So am i
615	Aznx	08.07.15:	Not to worry.
616	Aznx	08.07.21:	We should write it out
617	Aznx	08.07.22:	here
618	Quicksilver	08.07.24:	Aznx to the rescue lol

Here is a second example from a group of students working on a different problem called grid world where students explore the geometry of a world where everyone must always follow the grid and there is no movement in the space that is off the grid. In this example "meet_the_fangs" and "dragon" have been working on the problem and developing some more sophisticated ideas about how to solve the particular problem of navigating the grid. "Estrickmcnizzle" and "gdog" were quite quiet for a long time when they finally interrupted the interaction with "estrickmcnizzle's" comment "we aren't getting anything done."

218	estrickmcnizzle,	20:50 (19.05): we arent getting anything done
219	meet_the_fangs,	20:50 (19.05): any suggestion?
220	estrickmcnizzle,	20:51 (19.05): i dont know, maybe just a more simple problem
221	estrickmcnizzle,	20:52 (19.05): less time consuming
222	gdog,	20:52 (20.05): drop the questoin
223	dragon,	20:51 (19.05): I think I know the answer...
224	gdog,	20:52 (20.05): more simpel one that i can understnad plz :)
225	meet_the_fangs,	20:52 (19.05): ask the mod to put up thequestions
226	meet_the_fangs,	20:52 (19.05): or we can do the summer one

Estrickmcnizzle's comment opened the group to thinking about the problem, and possible solutions, differently. It also gave the two quieter members of the group different jobs to do in relationship to posting the group's solution and how to share those results with the VMT staff and other groups.

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 refers to as signification, legitimation and domination respectively.

Traditionally the structure of the classroom, and what agency is expressed, are transposed from other similar sittings. Thus the constraints of past experiences may significantly limit what actions students take. In these relatively new online chat environments, however, such structures, if they exist, are borrowed from purely social experiences (e.g., chat rooms, blogs). Thus in many cases the signification and legitimation are all 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 improvisations – the creative and unexpected making 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 you, we show that learning can be described as creative and improvised acts of agency – both individual and collective. The 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 opportunity to make creative problem solving decisions. It may also be that the types of students who are drawn to these settings are those that more familiar and comfortable with these newer social constraints. In the first example it is a problem that asks students to think about the relationship between the numbers of sticks one uses to make 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 very intimidating in a typical classroom setting. But in the VMT chat the students are creatively playing off of one another in order to make some 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 what new questions to ask. In the second example we see one pair of students having the agency to stop the more "knowledgeable" students and ask them to engage in a set of questions they can all understand. Again this is a remarkable breaking with traditional classroom norms.

Pulling back, agency, in some respects, requires individual and collective actions. When individuals begin to interact in coordinated or shared states of intentionality, forethought, self-regulation and self-efficacy, there is the converging and emergent values and beliefs – sensibilities and awareness of interdependencies, and interconnectedness. 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 does (may) benefit from the noticings (attending), problem solving, reasoning and reflections of individuals; and the awareness of the development of a shared culture, resources and social history – ways of asking questions, producing solutions to the math problems. So again in the second example the students work together to define the questions they want to answer. There is a pressure to collaborate and a scaffold to encourage all to speak and play with the problem.

Returning to Bandura's (2001) proposal that group achievement are the products of, and produced by, the interactive, coordinated, and synergistic dynamics of members' transactions, and not merely by the individual's intentions, knowledge, and skills, recall that transactions are an ongoing dynamic process that brings about a state of interconnectedness and interdependency (transformational process). Thus, because of transactional dynamics, the interconnectedness and interdependency of individuals with shared beliefs in their collective power and efficacy can result in the perceived group-level emergent property described here as a sense of collective agency. 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 students have the tools to play off of each other and enjoy the creativity of that play. This potential for a open and free interaction encourages individuals to be agentic, but it also encourages the group to feed the individuals and to get students to act like mathematicians, asking questions of the worlds they have created.

Conclusion

When one looks at the larger passages of interaction one sees this dance of creativity and agentic behavior more clearly. Our brief examples have been drawn from larger sessions where groups of students work in 3 or 4 sessions of about an hour to two hours. These sessions largely involved the same participants and so a sense of community was created among the students who worked together. In this larger set of data one can really see the ways that groups take up problems, define them, attempt to answer them, explain their answers and move on to new problems.

The VMT chat then has created something very unique. It has created an online world where students take control, define problems, respond to each other and then attempt to answer these problems. In this way they look more like professional mathematicians, in training, than students in a classroom. We would suggest that the VMT Chat environment has the potential to overcome the structural constraints that one might see on social action from a Giddensian or Bourdieuian 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 readily reproduce the hierarchies or power relations in traditional school settings. Though it can also be argued that eventually a certain kind of social network will develop based on the social interactions possibly producing hierarchies and power relationships.

Further, the social action that students engage in, in the VMT environment, creates new structural realities for their further work in that space. As Giddens suggests there is a self-conciousness to this social action and the

social action that is encouraged is creative and draws upon the participants' imaginations to see knowledge production as a fun, interesting and possible activity for ordinary people. Further understanding how to harness this agentic behavior and leverage it for deeper learning will be a next step for this research.

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Acknowledgments

We wish to acknowledge the entire team of researchers on the VMT project at Drexel University and in various international centers. In particular we wish to thank Gerry Stahl for his support and acknowledge the efforts of his graduate students, Murat Cakir, Johann Sarmiento, Ramon Toledo and Nan Zhou, for their part in collecting these data and helping us navigate the VMT systems.