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Problem Articulation and the Processes of Assistance: An Activity Theoretic View of Mediation in Game Play

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Abstract

In this article, we study a local adaptation of the 5th Dimension (Cole, 1996) known as Las Redes (i.e., Networks of Collaboration in the Fifth Dimension) to examine how the multiple activity systems of Las Redes, e.g., the undergraduate course and the school and university communities—all organized around cultural historical activity theories of learning and development—promote learning among undergraduate and elementary school children. In particular, the article focuses on a particular social situation of development in which the social organization of learning and forms of mediation available inspire new forms of participation and assistance. Activity Theory, as a present-to-future model of development, is used to examine how these developmental processes were structured through problem articulation (finding, identifying, and representing problems) during computer-mediated collaborative problem solving activities.

The properties of groups of minds in interactions with each other, or the properties of the interaction between individuals' minds and artifacts in the world, are frequently at the heart of intelligent human performance.

Edwin Hutchins, 1993

In a boisterous and lively after-school club, children participate in educational activities organized around several dimensions of play. This after-school club, Las Redes (i.e., Networks of Collaboration in the Fifth Dimension), is simultaneously a playful world and a collaborative culture where play organizes the goals of learning.[1] Problem solving in computer-mediated gaming activities becomes the basis for collaboration among elementary-aged children, university undergraduates, and urban educators who come together to create and nurture productive learning experiences for children and adults alike. In this article we examine how the multiple activity systems of Las Redes, e.g., the undergraduate course and the school and university communities—all organized around cultural historical activity theories of learning and development—promote learning among undergraduate and elementary school children. In particular, we focus on a particular social situation of development in which the social organization of learning and forms of mediation available inspire new forms of participation and assistance. The processes of problem articulation serve as the context in which to study how mediational processes are structured.

In contrast to more traditional educational settings, this site, as well as other Fifth Dimension (5^{th} D) after-school clubs, provide an informal learning context that thrives on diversity by

[1] Each 5th Dimension is a local adaptation of the organizing principles of the 5th Dimension (Cole, 1996) created 25 years ago. Each is distinct in the way it organizes learning, the activities offered, and forms of mediation employed.

utilizing different perspectives on the meaning of a problem as a resource for structuring mediational processes during problem-solving activities emerging in the course of everyday activity at Las Redes. The unique design creates a learning environment in which multi-aged participants who are members of various cultural communities are encouraged to coordinate their efforts on educational tasks. This emphasis on collaborative coordination, a distinguishing feature of Las Redes, is both "the product and the process" (Wertsch & Stone, 1979) afforded by the larger goals of this problem-solving environment. The overall intent of this innovation is to create normative practices in which all participants are actively engaged in learning. One important consequence of this overarching goal is that, in this playful world, competency for accomplishing a task is necessarily distributed among participants through their continual participation in communication, collaborative reasoning, and conversational reflection activities during joint problem-solving events.[2] Processes of collaborative coordination in these events necessitate the continual appraisal and evaluation of interaction in order for the coordination of talk and actions to be accomplished. It is in these events that mediational processes become not only integral to collaborative learning but also crucial in promoting self-regulated learning.

In this article, we examine the mediational processes of problem-solving events by focusing on problem articulation, that is, how problems and problem goals during game play are collaboratively identified, defined and represented over interactional time (cf. Stone, 1996a). In our discussion, we advance the position that problem articulation, enacted through social activity, is one dimension of the more general category of problem-solving discourse. From this perspective, problems are enacted through what people say and do, that is, through discourse. In

[2] Distributed intelligence in this article, following Pea (1993), refers to how "resources in the world are used, or come together in use, to shape and direct possible activity". From this view, Pea argues that intelligence is not

this way, discourse is a cognitive activity in which we transform our environment into a socially and culturally meaningful one (Goodwin, 2003).

The social processes of problem articulation are highlighted in this research to reflect current understandings about the situated nature of reasoning (cf. Carraher & Schliemann, 2000; Saxe, 1991), the interactional processes of problem solving (Stone, 1996b) and the organization of distributed intelligence (Hutchins, 1993). In the course of studying problem articulation at Las Redes, we observed that more experienced participants utilized different tools and forms of mediation to assist children's participation and understanding to accomplish tasks jointly. For example, undergraduate participants who had less experience with the cultural practices of Las Redes and its theoretical underpinnings organized a series of tasks that were conceptualized and enacted as discrete tasks, independent of the object (purpose) of activity to assist children's understanding of the tasks and promote self-regulated learning through co-regulated learning activity. In contrast, more experienced undergraduates, i.e., those who had been socialized to and through the cultural practices of the larger activity system of Las Redes, interpreted their roles and utilized resources differently. Of interest, these participants developed what we term a mediated serial—a process of assistance organized initially as a series of tasks by a more competent participant but that shifts over time into the hands of the participant with emerging competencies. How these problems are interactively articulated and enacted plays a significant part in organizing the mediational processes of problem solving in the joint accomplishment of learning.

The process of problem articulation is not context independent. The way individuals interpret and articulate problems, the mediational strategies they use, and how they define and

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possessed but rather accomplished in activity that is distributed "across people, environments, and situations" (p.

negotiate their roles and responsibilities for knowledge production are related to their local community and its history of practices (Goodnow, Miller, & Kessel, 1995). It is through the community's historical marking of particular norms, values and expectations for engaging in problem solving that influences problem interpretations. As a consequence, to understand how problems are articulated in this 5th D and how this process mediates learning and development, it is important to consider the interrelationship between the participants in the local after-school club and their growing understanding of the 5th D's historical emphasis on and value for diversity of thought and perspectives as resources for promoting self-regulated learning (Cole, 1996).

Theoretical Background

Theoretical grounding for researching the transaction between problem articulation and the social environment is found in sociogenetic perspectives on development, which focus on the emergence of future competencies through engagement in goal-directed activities (cf. Cole, 1996; Granott, 1993; Leont'ev, 1981; Ochs, 1988, Rogoff, 1990; Valsiner, 2001; Vygotsky 1978; Wertsch, 1991). Activity Theory (AT), a closely related theory, provides conceptual tools (e.g., rules, division of labor, mediational instruments for examining cultural practices as object-oriented, that is, analyzing human development as a mediated process intrinsically interwoven with the emergent and continually negotiated purposes or objectives of cultural practices (for a detailed analysis of AT, see Engeström, 1999, Stetsenko, 2005). For example, the object of learning practices in the 5th D is to promote agential, creative and self-regulated learners by valuing and utilizing diversity in its many forms during game play. As children and undergraduates collaboratively solve particular problems a multiplicity of goals arise during this process. As these goals are pursued, individuals simultaneously promote their own development

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49-50).

and negotiate, renegotiate, and bring into existence or potentially transform the object of 5th D learning practices. The learning practices in the immediate 5th D club, however, are not separate from other activity systems. Rather, participants bring multiple perspectives appropriated from their prior experiences in other practices (Engeström, 1999). Of import in this study is the ongoing conversations about the purposes and intent of the cultural system of Las Redes that undergraduates pursue in their university course—a practice, we will show, that influences more experienced participants' perspective on how to organize mediational processes during problem articulation in this particular 5th D.

In this work, we employ an expanded understanding of the theoretical construct of ensemble as a robust unit of analysis to examine participants' interpretations and collaborative negotiations of problems (Granott, Fischer, & Parziale, 2002). An ensemble includes the smallest group that co-constructs knowledge and the mediational tools and semiotic resources they use (ibid). Ensembles, we argue, are micro contexts of development that are embedded within and in a bi-directional relationship with the larger cultural context, in this case, the world of the Las Redes after-school club (Gutiérrez & Stone, 1999). In other words, ensembles offer an ecological site to study the development of problem interpretations and how these interpretations mediate learning through particular assistance and assessment strategies. This is made possible because problem interpretations create what Goffman (1974) calls "frames," i.e., definitions for the current social activity and the requisite roles needed to enact it. Participant frames, we will show later, lead to serial or mediated serial forms of assistance. Each of these forms is fostered by the maintenance or shifts in "footings," i.e., roles and responsibilities for knowledge production that are negotiated in the turbulence of ongoing activity (Goffman, 1974).

Research Questions

The following research questions were used to investigate how problems were interactively articulated in the after-school club:

1. How is problem articulation in ensembles collaboratively accomplished?
2. How are the social interactional processes of problem articulation mediated by the activity system of Las Redes learning community?

Methods

Activity Setting

The data in this study are taken from a larger investigation into the development of literacy broadly conceived to include domain knowledge such as language, mathematics, and science in a non-traditional educational setting, i.e., an after-school club, that privileges multiple languages, play and the imaginary situation, and dynamic participation structures. Las Redes after-school club is located in an urban school district with a predominantly immigrant Latino student population in the southwestern area of the United States. Children in this study are considered to be academically vulnerable by the school district and state assessment criteria. In the after-school setting, children worked three times a week with undergraduate students from a local university who were enrolled in a child development course and field practicum. The goal of undergraduate participation was to connect theory to practice by reflecting on and drawing from cultural-historical theories of learning and human development to assist children's performance on a range of tasks. Undergraduates conduct cognitive ethnographies (Hutchins, 2002) to document the moment-to-moment learning in ensembles.

The corpus of data consisted of five videotaped sessions of approximately one hour each in duration and 110 sets of participant observation fieldnotes taken by undergraduate students and undergraduate researchers collected over the course of an academic term. The criteria for the

data selection were related to identifying a specific computer game, in this case, Puzzle Tanks (PT), and all undergraduate fieldnotes (10) taken while engaged in this game (in order to do a comparison of the same gaming context over time). PT as a game context is designed for one player and consists of four levels of difficulty. The goal of the game is to measure out a specific volume of liquid by filling and emptying tanks as well as transferring liquid from one tank to another (O'Brien, 1985). PT provides complex mathematical problems by requiring children to utilize multiple arithmetic steps to produce a solution, while allowing for multiple solution paths. Consequently, unlike much of the mathematics curriculum in schools, the arithmetic problems in the Puzzle Tanks are characterized by levels of complexity unfamiliar to many elementary school children (Grows, 1992; Stone & Stone, 1997).

Participants

This study includes the learning of two ensembles. One ensemble (Ensemble 1) consisted of an undergraduate, Jossey, a junior who was new to the Fifth Dimension, and a second grader, Abel. A second ensemble (Ensemble 2) consisted of two children, Marvin and Giselle, a fifth and second grader respectively, and Mike and Rick, two undergraduates who were both seniors with prior experience with the course and field work the previous quarter. This combination of new and experienced undergraduate participants in ensembles made it possible to analyze undergraduate development during problem articulation by sampling fieldnotes and video data that characterized the nature of changing participation in activities such as defining problems and providing assistance.

Data Collection and Analysis

To document the social processes of collaborative problem articulation enacted across different points in time, cognitive ethnographies were conducted by student-researchers and

participating undergraduate students to capture routine social interactions and the persistent social and cognitive characteristics of game playing practices with computers in the after-school setting (cf. Hutchins, 2002). As previously mentioned, the involvement of more and less experienced participants produced both different ethnographic accounts of a single ensemble activity and various interpretations of the presented problem. Thus, each after-school club session could result in two sets of participant observation fieldnotes of an ensemble working together. In this article, we draw on one set produced by a novice undergraduate participating in an ensemble with one child (Ensemble 1), and another set simultaneously produced by more experienced undergraduate researchers who collected video data of Ensemble 1. We use these data to examine how a more experienced ensemble reflects on their own processes, as they observe how novices articulate problems at Las Redes. The data of Ensemble 2 consisted of one set of fieldnotes and video data.

Specifically, videotapes of ensemble activity with participants interacting at computers were collected to capture important details of social interactional processes of problem articulation. Since the most direct evidence possible about situated reasoning of problem solving occurs during social interaction, discourse and conversation analytic methodologies were also used (cf. Atkinson & Heritage, 1994; Duranti, 1997)[3]. In combination, these methodologies made possible a macro analysis of the emerging culture of Las Redes and a microanalysis of the moment-to-moment or microgenetic development of problem articulation processes arising during ongoing game playing activity. The communicative processes of situated problem articulation became the

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3 Transcription conventions used in this study were developed Gail Jefferson, (see Atkinson & Heritage, 1984). Specifically, ( ) indicates unclear speech, (( )) describes paralinguistic information about context, (.) are untimed pauses, (2.1) is an indicator of pauses in seconds and tenth of seconds, [refers to simultaneous start ups or overlaps, = notes contiguous utterances; :: specifies extension of sound; ↑ or ↓ indicates up or

means to determine what interactional opportunities and resources were available to ensembles during collaborative problem solving and how intellectual activity is shaped reciprocally by talk-in-context and the larger culture. The micro/macro approach in this study allowed for the documentation of several key dimensions: 1) how emergent competence, *qua* problem articulation, is organized and distributed among participants; 2) how problem articulation changes over time; and 3) the relationship between the larger cultural setting and the moment-to-moment production of knowledge (for a detailed description on micro/macro methodology for studying human development, see Gutiérrez & Stone, 1999).

Findings and Discussion

Identifying problems in the Fifth Dimension was frequently related to a presented problem, that is a well-structured, formally posed problem found in computer games (Getzels, 1976). These formally posed problems, such as "How can you make 27 by using the values of 9 and 3?" created a range of emergent problem types for both the undergraduates and the children at the after-school club. For children, emergent problems consisted of difficulties in determining the goal of the game, recognizing and understanding the formally presented problem, planning and implementing solutions, or using the available resources afforded by the activity setting. For undergraduates, emergent problems were related to how children responded to the presented problem. For example, children's emergent problems influenced how undergraduates negotiated the task definition, implemented productive assistance procedures, and utilized mediating tools. Since the larger goal of accomplishing these game-playing activities was shared, at least partially, these problem types, although different, were not disconnected from each other. Rather, they were part of the fabric of collaborative problem solving in this setting. As such, problem

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downward shifts in intonation, <u>underlined</u> or **bold** words indicates increased stressed, ! is an animated tone

articulation in the after-school club was not an individual process but rather a dynamic process that benefited from different perspectives on the presented problem. Thus, children's thinking became central to this collaborative process. Unlike what occurs in many learning environments where changes in footings are not supported, especially in formal learning environments, in this context participants are given tools to rethink their roles and to change their forms of participation and tool use.

How this process developed over time was related to undergraduates' growing understandings of the larger goals of Las Redes and its accompanying course, i.e., utilizing collaborative (other- and co-regulated) learning as a means of fostering independent (self-regulated) learning through their participation in a playful imaginary world where new forms of participation, stances, and shifts in footings (roles/responsibilities) are possible. As this understanding grew, undergraduates' interpretive frames for problems changed. This shift in activity frames resulted in dynamic and fluid changes in footings over interactional time, as a result of assessing and re-assessing children's understanding of the presented problem. This dynamic assessment led undergraduates to use assistance procedures in which they would initially offer direct instruction, followed by the sharing of a range of possible strategies, and ultimately the removal of their assistance. This sequence of assistance strategies resulted in a shift from finding correct solutions to providing general and specific problem-solving strategies as mediational tools. This sequence also supported children's growing competency with problem-solving strategies and their development of self-regulated learning.

It is not surprising that undergraduates' activity frames for interpreting problems also affected how children responded to game problems. Children's initial concerns tended to be limited to the

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marker, °xx ° is quiet talk in relation to surrounding speech, > < are rapid speech indicators.

immediate presented problem and its local conditions, that is, the problem displayed on the computer screen, the keyboard, and the mouse. As the undergraduates' perspectives on presented problems changed from an emphasis on correctness to an emphasis on strategies, children began to take on different roles and began to use other mediational tools in addition to the computer game, for example, drawings and graphs. Consequently, the continual shaping of problem interpretations, stimulated by a growing understanding of the cultural values of Las Redes Fifth Dimension, functioned as a resource for all participants in ensembles to take on different roles and responsibilities during problem articulation processes of game play.

The social processes of problem articulation

To demonstrate how problem interpretations and thus mediational processes of problem articulation shifted over time and influenced problem-solving discourse, we will draw on fieldnotes and video data collected by two veteran undergraduate researchers, Mike and Rick that document their co-participation in an ensemble with newcomers to Las Redes. In an excerpt from their fieldnotes shown below, Jossey, an undergraduate participant, is a new member of the Fifth Dimension; this is her second visit to the after-school club and is in the process of assisting a second grader, Abel. It is important to note that we view these data as describing only one moment in Jossey's developmental processes as a participant in the Fifth Dimension. It is precisely the fact that Jossey is new to the after-school club that makes Mike and Rick's reflection on how she and Abel articulate a problem interesting in understanding the relationship of mediational processes in problem solving to the larger cultural goals of this activity setting and game play. These cultural goals and values influence Mike and Rick's written reflection on collaborative game play. Further, their fieldnotes captured how problem articulation is not separate from the assistance strategies utilized by the undergraduates who participate in this

setting. In the activity documented in their fieldnotes, Jossey is helping Abel figure out how to create 21 with the values of 9 and 3 in the Puzzle Tanks game. What is important here is Jossey's sole reliance on directive assistance strategies. In doing so, Jossey took on the footing (commonly found in directive roles/responsibilities) of classroom teachers employing strict recitation scripts (Gutiérrez, 1993) and thus organizes the formally presented problem as a series of sequential steps (Gutiérrez, Crosland, & Berlin, 2001).

Fieldnote #1 Describing a Novice Undergraduate in an Ensemble

> Jossey was very directive. For example, in one game the goal capacity was 21 and the two other tanks were 9 and 3. Instead of just letting Abel go ahead with the game, Jossey took Abel through the process of completing the game step by step. First she said, 'What's 9 plus 9?' Abel replies, '18' and Jossey responds with' good!' Then she says, 'What's 18 plus 3?' and after a few moments of hard thinking Abel relies, '21.' After this was verbally done, Abel goes ahead and successfully empties out the tanks into the truck. For most of the session, Jossey used this type of technique. She would verbally take Abel through the addition steps and lead him to the correct answer. Her method for getting him to find the correct answer was to put the correct numbers in the equation and have him do the addition. She very rarely let him explore with the numbers and very rarely let him come up with different possible equations that could solve the problem. She pretty much gave him all the correct requirements and had him do the addition.
>
> (Mike & Rick, 1/28/97)

The undergraduate fieldnote excerpt shown above and video data suggest that throughout the game, Jossey maintained the same "teacher" footing throughout the activity and sectioned mathematical problems into their component parts for the children to solve. When problems are

segmented into component parts, they can be referred to as serials (Stone, 1996a). Serials organize problems in to a series of subtasks or discreet elements of the presented problem as illustrated in the diagram below:

Insert Figure 1 about here.

The above representation of a serially organized problem illustrates how the mathematical problem is broken into several smaller tasks or subgoals when accomplished in toto represent a completed problem. The subtasks of the serial in these data require Abel to fill in the missing sum by utilizing arithmetic facts (e.g., 9 + 9 = ?). The undergraduate, on the other hand, assumed the responsibility of selecting the numbers, the operations (e.g., addition), and the sequence of operations. In other words, Jossey interactively articulated the presented problem as one that required the child to produce only factual knowledge by providing the correct answer when she needed to use conceptual knowledge to determine subgoals. For Jossey, this was the most efficient method of collaborative problem solving, that is, to scaffold the problem in ways that define both means and outcome. Accordingly, assessment of mathematics and not the child's mathematical reasoning, became essential for the continuation of this activity.

The serial form of problem articulation illustrated here encourages assessment and assistance strategies that result in what Griffin and Cole (1984) call next-step assistance, that is, the parsing of a mathematical problem into step-wise tasks. In the case of serials, like the one illustrated above, next-step assistance organizes conversational talk, reasoning, and reflection activities as

primarily the undergraduate's responsibility for determining what to do next and when to do it. When the social organization of a mathematical problem is limited to serials driven by a goal of efficiency, it appears that next-step assistance becomes the primary form of scaffolding. We distinguish explicit instruction from next-step assistance that is often provided in lock-step fashion in ways that limit opportunities for children to produce complex mathematical understandings and, further, limit opportunities for children to become self-regulated learners. More to the point, we argue that explicit instruction employed strategically is an important but not sole element in the mediational toolkit. The implication is that while the reasoning used for accomplishing a serial problem is distributed to some degree, there are limited opportunities for children to struggle with a problem and thus few opportunities to experience some degree of cognitive conflict in interactively negotiating problems and little chance of reorganizing or modifying their present understandings (Piaget, 1954). Of further significance, when children do not have opportunities to make mistakes in which they test assumptions or try out strategies, and to display their thinking, it is difficult for a more experienced student or adult to determine appropriate assistance strategies (Rogoff & Gardner, 1984). In this article, we define appropriate assistance strategies as those in which the transfer of responsibility for learning shifts strategically from the instructor or to the child as competence with mathematical problem solving begins to emerge (c.f. Gutiérrez & Stone, 2002).

In contrast to Jossey, Mike and Rick view the presented problem differently. These undergraduates are already familiar with the program goals of promoting both self-regulated and co-regulated learning by utilizing concepts from cultural-historical theories of learning and development. As they reflect on the practices of this novice undergraduate’s participation in the

ensemble, their analysis reveals a different interpretation of the presented problem and also how they would change the nature of the child's participation.

Fieldnote 2: Mike and Rick's Analysis of the Problem

> Though Abel got the problem correct, it does not mean that he understood the game. From this interaction, it is evident that Abel can do simple addition, but we are unable to see if he knows how to figure out how to make 21 from 9 and 3. In being so directive, Jossey did not allow for the game to serve its purpose. If the game was about simple addition, there would have been just a simple addition problem on the screen. Abel was never given the chance to experiment with the game, and could not demonstrate to us whether he understood the concept of the game.
>
> (Mike & Rick, 1/28/97)

In this excerpt, the undergraduate researchers identified the "real" problem as one of requiring comprehension both for the overall task, as well as the skills needed to accomplish the components of the task, i.e., the mathematical operations and their sequence. From this interpretation, the accomplishment of mathematical components of any individual problem, e.g., 9 + 9 or 18 + 3, are not the sole end goals. The undergraduates' notes suggest that they see the presented problem in the game as an opportunity to assess children's comprehension when they claim, "[Abel] could not demonstrate to us whether he understood the concept of the game." Additionally, Mike and Rick wanted to know if Abel could "figure out how to make 21 from 9 and 3." The significant point found in these fieldnotes is the expectation for children to be able to do mathematical problems with some mathematical skill, as well as some conceptual understanding. The important questions here are: a) How are these reflections and views from veteran participants translated into practice in the after-school club? b) Are there differences in

the discourse of more experienced participants? and, c) Do these differences result in new practices that create beneficial learning opportunities for children?

The answer to these questions are found in another set of fieldnotes and video data in which Mike and Rick had the opportunity to work as part of an ensemble with two children, Marvin, a fourth grader, and his sister, Giselle, a second grader (Ensemble 2). These two children were new to Las Redes. Consequently, this is their first time playing Puzzle Tanks. To begin the game, Mike and Rick ask Marvin to read the game directions. After Marvin finishes reading the directions, the undergraduates note in their fieldnotes that Marvin moved "the mouse from object to object, not knowing the significance" of the presented problem on the screen. Mike responds to Marvin's behavior by re-explaining the goal of the game. This explanation shown in the excerpt below can be contrasted with Jossey's approach to assistance and assessment.

Figure 2: Marvin, Giselle, and Mike

Excerpt 1: A Veteran Participant Explaining the Goal

Mike: Do you know: what the ob:ject of the game is:? 1

Marvin:	No:::.	2
Mike:	You see, you ha::ve	3
	The object of the game is to fill this truck right here	4
	((Pointing to the screen.))	5
	You have::	6
Marvin:	(.....)	7
	((Watching Mike point to the screen.))	8
Giselle:	*((Watching Mike point to the screen.))*	9
Mike:	You see you're gonna use these two:: tanks:::	10
	And:: this one's four:::,	11
	One:: two:: >three, four<	12
	((Pointing to the screen as he counts))	13
	(0.4)	14
	And:: this one has two::	15
	And the goal: is to fill up the truck is twelve:::.	16
	So:: they they tell you the goal:: right here okay::	17
	They use these ounces to fill up the truck::.	18
	(0.9)	19
	And then: you could like use:: the arrows to move	20
	the uha	21
	>You know< you might wanna try clicking on the	22
	arrows and see what they do::.	23

In this example, Mike brings Marvin into the assessment process with an evaluation question, “Do you know what the object of the game is?” Marvin's response, “No....” works to confirm Mike's prior assessment of Marvin’s lack of comprehension, while simultaneously creating an opportunity space for producing a re-explanation of the game goal. Initially, Mike's explanation explicitly states the goals of the game and details how to use the on-screen tools to achieve the goal (lines 10- 18). The language Mike uses to accomplish the initial part of the explanation is characterized by directness and certainty. For example, Mike states that the goal of the game “is to fill this truck right here...”(lines 4-5)**.** He follows this information with specific instructions about how to use the on-screen tools, thus, anticipating future activity (line 10). This part of the explanation sequence is an implied directive. It is accomplished with a modal verb (“going to”) and an infinitive (“to use”) to imply future fulfillment of the present, “You see you're gonna use these two tanks” (Gutiérrez, 2005; Quirk, Greenbaum, Leech, Svartvik, 1985; Stone, 1994). In other words, this first part of the explanation includes an expectation for the child to use explicitly given information to accomplish the game. This interaction reflects an interpretation or frame that required Mike to take on a footing of “director” of learning, a teacher footing common to more formal learning settings. Notwithstanding the initial directness of the explanation, Mike changes his footing and, thus, his language, as the explanation is concluded; in doing so, he moves from giving more explicit information to providing potential strategies for Marvin’s consideration. Specifically by using the modal auxiliaries *might* and *could* (lines 20, 22), this veteran participant creates an interactional context characterized by both a theoretical possibility and a hypothetical situation for Marvin’s consideration (Gutiérrez, 2005; Stone, 1994). Thus, the use of these verb auxiliaries created a tentative and future-oriented situation in which Marvin had potential opportunities to explore or to reflect on different strategies. By utilizing these particular

linguistic resources, the undergraduate signaled a change in the social situation of development, as well as a shift in expectations for how the child could and would participate; these changes resulted in the possibility of moving from co-regulated to self-regulated learning.

In co-regulating learning, Marvin had the opportunity to decide, to some extent, what needed to be accomplished with respect to the presented problem. In particular, this child had the opportunity to define the subtasks or subgoals of the presented problem, i.e., determining what needed to be done and how. The organization of this explanation created the possibility for reasoning to be distributed more evenly between child and adult. Further, the veteran undergraduates gave Marvin enough assistance to accomplish the task on his own and also expected him to do so ("After the first game, we thought that he pretty much knew how to play the game but just had to get used to it."). In this way, Marvin was able to define the subgoals of the activity with little intervention. Not unexpectedly, Marvin continued to explore and play the Puzzle Tank game. He eventually finished the first game after "ten [quick] tries." These veteran undergraduates, guided by Cole's heuristic of providing "just enough" assistance (personal communication, October, 1996), created a zone of competency, i.e., a zone of proximal development (Zoped) in which changes in footing promoted a shift from co-regulated to self-regulated learning.

Recurrent changes in footing, and, thus, participation, characteristic of the kinds of zones of competency found in this setting were not limited to co-defining the problem through assistance strategies. Children also had frequent opportunities to produce explanations for other participants. For example, after Mike and Rick decided that Marvin understood the game, they asked him, "Do you understand the game?" followed by "Do you think you can explain it to Giselle?" Marvin replied by stating that he understood the game and also by beginning to explain

the presented problem to Giselle. When members of an ensemble, as illustrated in the excerpts below, are given opportunities to create explanations, for example, this is a shift in footing for the novice participant and promotes the use of different cognitive skills. Why Mike and Rick realized this was an opportunity for Melvin to take on a new role in knowledge production is related to their understanding of the Las Redes activity system and its object, i.e., promoting self-regulation through co-regulation. The following excerpts will show two phases of this child's explanatory activity, one in which Marvin provides stepwise game directions without explaining his reasoning, and another explanation where he provides the details of his thinking.

Excerpt 2: Shifting Participation--Doing to Explaining

Marvin: *((Talking to Giselle as she looks at the computer screen.))*

You have to get fifteen::. So::: what do you wanna put down first?

You wanta put down six:: or do you wanta put down three.

(1.4)

Put down _six::?

(0.8)

Okay:: now: how many more do you need to get fifteen?

How many more do you need:?

Use your fingers to do it.

You call it three, four, five, six, seven, eight, nine, ten, eleven,

twelve, thirteen, fourteen, fifteen.

So you need twelve.

Now put your hand here and take this one.

((Helping his sister use her fingers.))

Put this one up to 20 and then fill it up like that.

Rick: Good job.

In the above excerpt, Marvin first tells Giselle exactly what needs to be done, "You have to get fifteen," followed by specific instructions and directions about how to accomplish the task. Interestingly, Marvin, like Jossey, uses stepwise assistance strategies and thus defines the presented problem as a serial. Mike and Rick notice that Giselle cooperates with Marvin and accomplishes the subtasks. However, similar to their earlier analysis of a serial in which Abel's participation and learning was limited, they conclude that Giselle did not have access to mathematical reasoning, i.e., why Marvin selected his particular strategies. In this situation, the undergraduates suggest to Marvin that he play the game again but add, "Tell her how you think." Marvin's response is to give Giselle some more details about his thinking, see below.

Excerpt 3: Shifting Participation--Explanation of Reasoning

Marvin: All right. (Can you see) which gets closer to twenty-five?

First: you see which gets closer to 25.

And then you:: I choose the 9 because it was closer to 18

and that was the closest you could get.

That's the one you could do.

So 18. You count with your fingers count with your fingers to get

to 25.

When Marvin produces the above explanation, the nature of his participation is expanded beyond the use of game playing strategies to include more conceptual understanding of the game. In other words, the undergraduates were supporting Marvin's development of assistance strategies that resembled mediated serials. In doing so, Marvin not only began to take on

different interpretations of the presented problem but also promoted his own development through an explanation. Following Cole (1997), we argue that explanations involve different cognitive tasks in which one skill is translated into another. Cole's interpretation of the Piagetian notion of reflective abstraction is useful in understanding how development may occur here. As Cole suggests, "...the importance of formulating one's ideas in language for others also serves as a potential moment of cognitive growth. First, in communicating about the content of activity to another, children routinely need to transform their figurative knowledge into conceptual knowledge." By asking the child to explain how to do the presented mathematical problem, Marvin now has the opportunity to move from doing the activity to articulating his understanding (the identification, definition and specification of the subtasks of the problem). In doing so, Marvin is transforming one form of knowledge into another. Marvin's explanation is an example of how children potentially construct new knowledge as the nature of their participation is reorganized through changes in footings.

In the Las Redes 5th D after-school setting, then, the joint activity of problem articulation creates multiple opportunities for varying what children do in routine activities; moreover, such dynamic interactional contexts engender normative practices in which changing expectations and changing ways of participating become the basis for utilizing different problem-solving resources, i.e., language, tools, and footings. It is through these resources that competencies for accomplishing the activity are distributed among participants. Of significance, children are expected to be active participants in their own development by co-determining subgoals of the presented problems and thus changing the nature of their participation by reorganizing the learning context. The arrangement of problem solving as both a collaborative and an individual process is related to the larger cultural goals of the 5th D that is based on the assumption that both

the adult and the child are involved in a bi-directional process of knowledge production and learning. What is important here is the interrelationship that exists between the object of the larger cultural setting and the microgenetic processes of learning. Over time, the agential and ever-changing negotiations of the object of Las Redes after-school club continually redefines and, thus, constrains what constitutes purposeful actions for the child and the undergraduates. These object-related actions are where the psychological processes of the present take shape and influence future development (cf. Stetsenko, 2005). Furthermore, since more experienced participants were expected to hand over responsibility for learning to the child, the constraints of this cultural context afford future changes in participation. As a consequence, the actions of undergraduates and thus children are continually transcending the immediate context by assessing their moment-to-moment actions and changing their behaviors and the activity in their negotiations of the object of 5th D practices (Valsiner, 1997). Moreover, contextual support for changes in footings for all participants created the circumstances in which children could be active in determining how to appropriate and use assistance; the personal agency of the child is realized as he or she determines in part the course of individual development

One of the primary ways children could potentially change their behaviors and the organization of learning in this setting, as we have seen, was by co-defining and representing mathematical problems. The processes of co-defining problems were often made possible through the use of cognitive tools such as diagrams and graphs. For example, as the complexity of the presented problem became increasingly more difficult, Mike and Rick began to notice that "Marvin was having a bit of trouble figuring out this problem" as he just sat and looked at the screen. The undergraduates response to this assessment is very telling, "All of a sudden we got a flash of brilliance; we got out paper and pen and told Marvin that he could use it to write things

down on to do the problems." After providing Marvin with the idea of planning out his solution on paper, he not only appropriated this planning strategy by determining how it needed to be used but also used it strategically throughout the game. What is more interesting is that Marvin did not tend to guess at answers when they involved multiple steps with varying operations. Rather, he consistently planned out his solution sequences on paper prior to giving an on-screen answer. For this reason, Mike and Rick not only encouraged the use of a tool as a way of thinking about problems but also encouraged the use of reflective practices in a computer gaming situation. Once again, variation in forms of participation created the conditions for children to mediate their own learning, in this case, through the use of tools.

Shifts in assistance strategies in which learning was co-determined created a very different goal structure from serially presented problems. This shift lead to what we refer to as a mediated serial in that it gave children the resources to mediate both present and future mathematical behavior. We call this a mediated serial; see diagram below.

Insert Figure 3 about here.

The mediated serial differs from the serial in that both the child and the adult contribute to the enactment of a problem by co-determining subgoals of the presented problem. The mediated serial stands in stark contrast to the first example of a serial in which the tasks or subgoals of the problem are predetermined by an undergraduate in order to accomplish a mathematical solution efficiently. The interactional processes of the first serial were not aimed at the negotiation of

subtasks but rather correct mathematical facts. This particular serial, then, had a central focus on mathematical problems and solutions. Although social interactions in this first serial lead to the correct production of mathematical facts, these correct answers were not necessarily a consequence of children producing new conceptual and procedural knowledge. Thus, non-mediated serials do not tend to occur in the zone of competency of the child or the ensemble since they are not organized around the emergence of new mathematical competency or greater understanding of children's reasoning. As a result, non-mediated serials do not promote individual agency in shaping future development.

Conclusion

In this study we examined the mediational processes of collaborative problem solving through the lens of problem articulation in a specific learning community. Participation in this community and a growing and negotiated understanding of the history of its cultural practices, we argued, played a significant role in the problem-solving discourse of more experienced members. Following D'Andrade (1992), we see in this work how cultural models motivate and are directive of human behavior. For example, less experienced members tended to use discourse practices that indexed a focus on teaching rather than learning by interactively producing a serial or lock-step and highly directed enactment of a problem. In the case of Jossey, we argue that understanding the presented problem as the accomplishment of a series of tasks is related to a pervasive "cultural model" or "culturally formed cognitive schema" of teaching and learning as adult directed (Holland & Quinn, 1987). Here, Jossey's forms of assistance index a traditional approach to teaching—a view highly influenced by behaviorism and its underlying assumption that the source of knowledge is the environment (Greeno, Collins, & Resnick, 1996). We might expect that an instantiation of this particular cultural model would render the teacher

responsible for organizing, analyzing, and directing when and how knowledge is produced. Of consequence for the participating students, this cultural model is in contradiction with the object of Las Redes' learning practices, and its underlying theories studied in the university course for participating undergraduates.

While the "object" or purpose of any practice is not simple, pre-defined, or pre-existing, the historical purpose of a practice, including the history of Las Redes, can serve as a resource to individuals as they negotiate and bring meaning to the practice. In this way, we understand that social structure does not predetermine the object; instead, the object of activity is always coming into existence as individuals locally and continually negotiate its meaning. At the same time, we documented how intellectual development was promoted as the students became more aware of the contradictions existing between the historical or widely accepted views of teaching and the way learning was organized at Las Redes. In the specific case of Mike and Rick, their growing understandings about teaching and learning from the course and their reflection on and analysis of Jossey and Abel's role in problem solving reflect their new understandings and provide evidence of an emergent model of teaching and learning through problem solving. These understandings reshaped how they used assessment to structure changes in participation. Specifically, their use of questions, explanations, co-problem-solving, and co-cognizing about mathematical problems and artifacts helped to create dynamic assessment strategies that, in contrast to Jossey, facilitated shifts in footings (Gutiérrez & Stone, 2002).

It is this new and continually developing cultural model that lead Rick and Mike to reorganize learning and use mediational artifacts creatively and responsively. Further, their assessment strategies enabled them to provide strategic assistance in the form of an explanation in which two forms of assistance were embedded: 1) explicit information, and 2) adaptable

strategies for mathematical problem solving. The explicit information served as a resource for children's understanding of the game, while the adaptable strategy provided heuristics for future problem solving. Moreover, the use of these informational and heuristic resources helped distribute responsibility for defining and accomplishing problems and, thus, distributed the thinking needed in problem solving. Of significance, in jointly articulating problems, these more experienced undergraduates kept children's mathematical knowledge and reasoning at the center of the problem-solving activity through ongoing and responsive assessment. In doing so, they created an instructional context in which a dynamic shift in the responsibility for learning between undergraduates and children could occur as children developed mathematical problem-solving competency.

These data suggest that when adults focus on learning rather than teaching, their continual reflection-in-activity leads to assistance strategies that become the potential resources for children's learning processes. In the present study, experienced undergraduates' practice of interweaving different forms of assessment and assistance strategies lead to changes in children's participation over time. The combination of explicit and adaptable strategies furnishes children with baseline knowledge for accomplishing the presented problem and affords children opportunities to determine how and when to use various strategies. As a consequence, the child's form of participation shifted from receiver of explicit information to one of sole or co-decision maker. These shifts in participation stimulate collaborative coordination both on the larger object of the activity and the emergent goals of the individual. Thus, the larger cultural purpose of promoting individual learning through collaboration is organized by Mike and Rick as they co-determine the sub-goals with the child. In this way, the social situation of development and the participants are mutually constitutive.

Of significance here is that the interactional events produced through dynamic assessment activities became constitutive of the microgenetic processes of learning for the child and the adult. This learning is evident in the children's ability to mediate their own learning by reorganizing their learning environments and completing mathematical problems formerly out of their reach. In this way, conversational reasoning and conversational reflection activities during ongoing collaborative problem-solving events advance cognitive development. If we understand an ensemble as a micro world of development, then, this learning context included both the child and the adult. As children begin to take on the cultural knowledge inherent in the presented mathematical problem and simultaneously begin to reason autonomously, the interaction between culture and individual development becomes more apparent.

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