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Telementoring Physics: University-Community After-school Collaborations and the Mediation of the Formal/ Informal Divide

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Telementoring Physics: University-Community After-school Collaborations and the Mediation of the Formal/ Informal Divide

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Communication and Cognitive Science

by

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2013

The Dissertation of Robert A. Lecusay is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego

2013

DEDICATION

To Lotus and Amalia.

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ABSTRACT OF THE DISSERTATION

Telementoring Physics:
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by

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Doctor of Philosophy in Communication and Cognitive Science

University of California, San Diego, 2013

Professor Michael Cole, Chair

For several decades improvement of science education has been a major concern of policy makers concerned that the U.S. is a "nation at risk" owing to the dearth of students pursing careers in science. Recent policy proposals have argued that provision of broadband digital connectivity to organizations in the informal sector would increase the reach of the formal, academic sector to raise the overall level of science literacy in the country.

This dissertation reports on a longitudinal study of a physics telementoring activity jointly run by a university-community collaborative at a community learning

center. The activity implemented a digital infrastructure that exceeds the technical and social-institutional arrangements promoted by policy makers. In addition to broadband internet access (for tele-conferencing between students at the community center and physicists at a university), supplemented by digital software designed to promote physics education, the activity included the presence of a collaborating researcher/tutor at the community learning center to coordinate and document the instructional activities.

The current research revealed a fundamental contradiction between the logic, goals, and practices of the physics instructors, and the corresponding logic, goals, and practices of the participants at the community learning center. This contradiction revolves around a contrast between the physicists' formal, logocentric ways of understanding expressed in the ability to explain the scientific rules underlying physical phenomena and the informal, pragmatic orientation of the youth and adults at the learning center.

The observations in this dissertation should remind techno-enthusiasts, especially in the arena of public education policy, that there are no turnkey solutions in "distance" science education. Technically "connecting" people is not equivalent to creating conditions that expand opportunities to learn and a functioning socio-technical system that supports learning. Secondly, for designers and practitioners of informal learning in community-university collaborative settings, it is critically important to understand distance learning activities as developing "cross-cultural, " collaborative encounters, the results of which are more likely to be hybrids of different ways of learning and knowing than the conversion of informal learning into a tool for instruction that will allow youth to "think like physicists."

CHAPTER 1: University-Community After-school Collaborations and the Local Mediation of the Formal/Informal Divide

For some time now after-school programs have been seen as an important tool for delivering science learning resources. These programs increasingly use the internet to promote science education by providing access to educational software and connecting learners with science-literate instructors through telementoring activities. In this dissertation I argue that the digitizing and delivery of science instruction through internet-based telementoring is not sufficient for implementing quality after-school science education. All instruction, whether facilitated by the internet or not, is mediated by persons through local cultural practices and artifacts. A careful approach to designing and implementing science telementoring activities, I argue, must understand those activities as "cross-cultural" encounters among the practices, artifacts, and values of the people involved in these activities or they face almost certain failure.

A useful starting point for considering the current project is the report published by the U.S. Department of Education's Office of Educational Technology as part of the 2010 National Educational Technology Plan, *Transforming American Education: Learning Powered by Technology.* The document outlines ambitious proposals to revamp the country's educational infrastructure. Its recommendations are directed at producing large-scale changes in how technologies are designed and deployed for educational purposes. They include national goals to deploy digital technologies as tools for thinking and communicating about academic content, and facilitating communication between educators, scientists, and students. Bridging geographic distances is a key function of the technologies. These policies assume a form of "direct instruction" in which adequate communication is provided by the digital delivery systems; however, they ignore the ways in which what is communicated is locally interpreted and organized. I will argue that these proposed policies are insufficient.

These policy proposals are meant to democratize education by delivering educational resources to a broader segment of the school-age population than was previously feasible. In the words of the report, learning resources should be designed to "exploit the flexibility and power of technology to reach all learners anytime and anywhere," and to draw on advances in technology and the learning sciences to "develop, adopt, and evaluate new methodologies with the potential to enable all learners to excel in STEM" (science, technology, engineering, math; U.S. Department of Educations, 2010, p. xii).

In addition, the authors of the report argue that new digital technologies should be recruited to "provide access to the most effective teaching and learning resources, especially where they are not otherwise available, and to provide more options for all learners at all levels," (*ibid,* xiii). In order to guarantee access to the requisite digital resources, the document stipulates that students and educators must have the appropriate material resources for use in *and* out of school, including at least one internet-enabled device, as well as reliable broadband and wireless connectivity (*ibid.*).

These proposals reflect a parallel concern among educators, policy makers, researchers, parents, and caregivers: the issue of "opportunities to learn." Opportunities to learn is a phrase used in the education research literature to refer to the conditions deemed necessary for a student to be able to learn something of social value (Moss et al., 2008). Obviously, these conditions vary depending on the context of the learning activity. Whether in or out of school, however, opportunities to learn have historically been defined in relation to classroom assessment practices (Pullin & Haertel, 2008). From this perspective, students are afforded appropriate opportunities to learn if they have access to the resources that will allow them to perform well on school-honed assessments. In other words, learning is understood in narrow terms as the acquisition of “testable,” disciplinary knowledge.

Recent scholarship seeking to improve upon this test/discipline-centered perspective on opportunities to learn has identified a set of “ingredients” that are considered fundamental to creating opportunities to learn: instructional *content*, *resources*, and *practices* (Pullin & Haertel, 2008). *Content* refers to the information and methods that students are expected to learn; *resources* are the materials necessary for delivering the content (e.g. books, software, supportive services, and infrastructure); and *practices* are the culturally embodied models of instruction and institutional context necessary for enacting the educational activities that bring together the content and resources for the “opportunity to learn.”

While Pullin and Haertel (2008) use the term *resources* to refer to material means for supporting learning, the term is applicable to the remaining ingredients for opportunities to learn. Content is a conceptual resource. Practices are social resources. I refer collectively to content, practices, and resources as *teaching/learning resources.* Here and throughout the dissertation I wish to emphasize something that tends to be rendered invisible in conversations about resources and education: the fact that it takes *people* to create, coordinate, and implement these resources in ways that effectively accomplish teaching and learning.

1. Opportunities to Learn After School

Learning Powered by Technology foregrounds a policy goal of connecting students and educational resources "anytime and anywhere." This goal is motivated by a concern for securing access to appropriate teaching/learning resources for every student. It also converges with recent recommendations by those interested in the potential of out-of-school settings for supporting STEM education. Attention to out-of-school arises because these settings, in contrast to classrooms, presumably afford the flexibility required to incorporate self-directed, project-oriented activities recommended by STEM researchers and practitioners (National Research Council, 2009).

Out-of-school settings, in other words, are increasingly viewed as affording opportunities to learn markedly different from those possible in a standard classroom. They appear amenable to integrating a growing variety of digital technologies used by scientists themselves, or seen as useful to helping learners think about STEM content. Not only must a technologically-driven after-school infrastructure for STEM activities be built, it must also be integrated into vetted instructional content and practices. Staff must be recruited and trained in the content. Pedagogical practices must support engaging learning activities.

In an ideal world, all of these conditions would be met; however, this complex combination of technical literacy and pedagogical skill, and the resources to support them are rare in after-school programs of any kind. Most programs are generally hard-pressed to maintain staff, and thus rely on standard homework activities or occasional enrichment activities (Eccles & Gootman, 2002). This situation is especially dire in low-income and rural areas where resources for attracting STEM-literate instructors are scarce.

2. School vs. After-school

Much of the discourse about leveraging after-school to increase school performance through increased opportunities to learn assumes that the goals and practices of the school can be easily modified to fit into after-school. However, it has long been believed that there are fundamental differences between schools and after-school institutions that make the design and implementation of such programs relatively problematic. This literature focuses on what we might call the "school/after-school divide," (Scribner & Cole, 1973; Strauss, 1984).

A useful entry point into current thinking about the school/after-school divide is the distinction between formal and informal learning. Livingstone (2006) outlines a rubric for distinguishing different modes of learning. Distinctions in this rubric are made with respect to knowledge traditions (rational/scientific vs. practical/situational) and the degree of agency a learner exerts in the learning situation (from dominant teacher control to dominant learner control). Drawing on the work of Molander (1992), Livingstone characterizes the rational/scientific tradition as "a rational or scientific cognitive knowledge form that emphasizes recordable theories and articulated descriptions as pre-established, cumulative bases for increased understanding," (Livingstone, 2006, p. 203). He characterizes the practical/situational tradition as a "tradition that stresses direct experience in various situated spheres," (*ibid*.).

From this perspective *formal learning* assumes a more expert authority figure tasked with teaching intentionally-organized, pre-established bodies of knowledge ("externally imposed curricular criteria") to learners who typically do not voluntarily submit to this instruction (Livingstone, 2006, p. 206). *Informal learning* involves learners voluntarily participating in an activity whose learning trajectory they actively shape. While these trajectories may be driven by the practical/situational concerns and interests of the learner, they may also incorporate organized, disciplinary knowledge. The key distinction between the formal and the informal is that the informal learner is voluntarily pursuing this knowledge.

Livingstone's characterization of formal and informal learning maps well onto a longstanding discourse about the relationship between school and after-school where schooling is the institution representing the formal, and after-school is seen as privileging the informal. This mapping is enriched by discussion that characterizes formal settings as ones in which both the goals and the means of activity are prescribed, while those in informal settings are negotiated. As we shall see, the actual conjoining of formal and informal modes of teaching and learning in the activity examined in this dissertation poses a number of dilemmas and provides an interesting way to understand the two logics.

3. Telementoring-based University-Community After-school Collaborations

Clearly, organizing the time, staff, tools, and space necessary to connect students with sufficiently expert instructors during after-school is no easy task. One solution has been to create partnerships between colleges and universities, on the one hand, and schools, after-school, and a variety of other arrangements whereby college students engage community youth in a variety of ways (Bevan, B., Dillon, J., Hein, G. E., Macdonald, M., et al., 2010; Eccles & Gootman, 2002; Schensul, 2010). These activities run the gamut from individualized tutoring via the internet, or *teletutoring*, to conventional classroom style lectures, to project-based *telementoring* activities. Such projects use technologies like email, web-based distance learning platforms, and desktop video chat to implement telemediated activities between geographically distant students and student-instructors (Bennett, Hupert, Tsikalas, Meade & Honey, 1998; Kochan & Pascarelli, 2005; O'Neill, 1998).

The current project took place as part of an ongoing effort to create University-Community partnerships based upon undergraduate practicum courses. In this kind of arrangement, which provided the circumstances for the current project, a university department provides supervised practicum courses in which undergraduates spend a significant part of their class time at an after-school program to engage in program activities and learn to analyze behavior in cultural context. In reciprocity, the community organization provides space, and shares supervision of the undergraduates. The community also provides overall activities at the site, and responsibility for local youth of varying ages with whom the students can interact around mutually agreed-upon activities. The community gains resources, both human and cultural, that the practicum arrangement brings to their youth. The aim of this form of the organization of the partnership is to achieve reciprocal relations of exchange (Vasquez, 2003). Each member of the partnership gives needed resources; each receives, in kind, resources that they need. Such systems are referred to as U-C Links.

The research project reported here was unique in U-C Links work. In collaboration with colleagues from my home laboratory, the Laboratory of Comparative Human Cognition (LCHC), I participated in the implementation of a physics telementoring activity, called the *Physics Learning Activity* (hereafter, the PLA), between a Community Learning Center (hereafter SDLC) in a federally-subsidized apartment complex in San Diego, California with university physicist-educators located in, Colorado.

I occupied both a community and a university role, ignorant as I was of physics. I was actively involved in the implementation of the PLA project to ensure that the program was seen as successful both by LCHC's colleagues in Colorado, and by the SDLC youth who were there because they wanted to be there. It was my role to facilitate the interactions between the physicists in Colorado and the local youth, both during online video conference sessions between the two sites, and in local off-line sessions in which the local youth and I engaged in hands-on activities based on what we had been exposed to in the video conference sessions.

An essential feature of this arrangement is that it places me directly between the physicists and the youths, permitting me a deep understanding of just what it means to provide appropriate opportunities to learn STEM subject matter in the after-school hours.

4. Theoretical Considerations

In order to develop a conceptual handle on the overall structure of the PLA, as well as to analyze interactions relevant for understanding the teaching and learning that took place, I drew on a number of theoretical traditions:

1. Cultural Historical Activity Theory (hereafter CHAT), one of a family of approaches for studying learning and development that focuses on the mediation of human action in its social, cultural, and historical context and on changes in how these systems are organized over time.

2. The study of "idiocultures," the local cultural formations that arise in small groups which provides tools for understanding the meaning-making processes that are taking place in the teaching/learning interactions of central interest.

3. *Distributed Cognition*, an approach to the study of cognition where mind is conceptualized not as something that one possesses, but as the complex and patterned forms of coordination among individuals and their culturally-constituted environments.

4.1 Cultural Historical Activity Theory

Rooted in the Russian psychological tradition initiated by L.S. Vygotsky and his colleagues (Leont'ev, 1978, 1981; Luria, 1971; Vygotsky, 1929, 1978), CHAT approaches are grounded in the idea that psychological processes emerge through active appropriation of the cultural tools made available in the social environment and their deployment in joint, mediated activity. Human activity is understood as a situated (Lave, 1988) *system* of culturally-constituted and historically contingent conditions (Cole, 1996; Engeström, 1987; Wertsch, 1998).). CHAT enters into the design, implementation, and analysis of the telemediated projects described in this thesis in a number of ways.

To begin with, as noted, the PLA was a joint enterprise involving two institutions, one centered in a local community organization, the other centered in a university group of physicist-educators. This basic organization is depicted in its most simplified form, below.

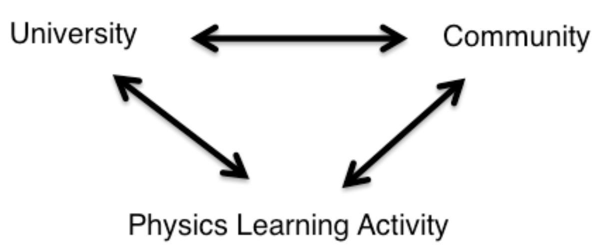

Figure 1.1: The Physics Learning Activity was an activity created through the joint activity of two kinds of institutions, one a university, the other a community organization.

This highly generalized formulation can be usefully fleshed out by incorporating the analytic categories introduced by Engeström (1987) in which any activity system is conceptualized in terms of the various means (tools, community, rules, division of labor) that mediate the interaction between persons and environment, as well as by the objects of activity:

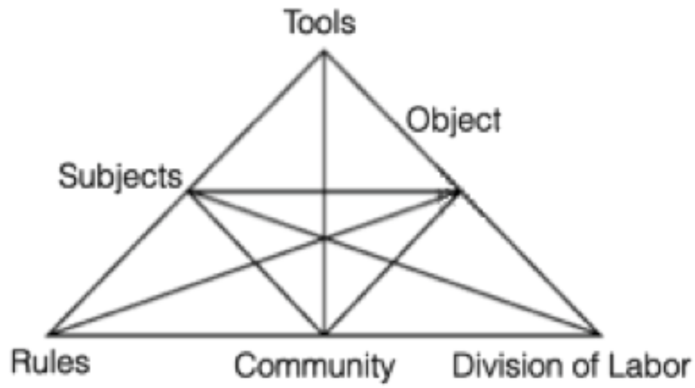

Figure 1.2: A basic CHAT representation (Engeström, 1987, p. 78). of the constituents of a human activity to enable analysis of transformations productive of socially valued outcomes - in the present case, learning the basics of electronic circuits.

In recent years, CHAT researchers have turned their attention to outcomes that emerge from the joint efforts of two or more institutional sources. For example, Engeström (2001) depicts the interaction of two such activity systems, using the following diagram:

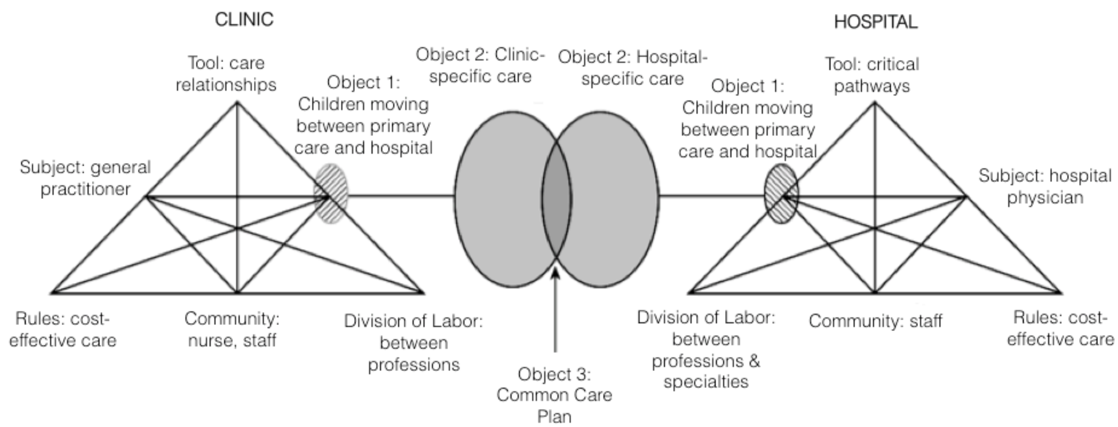

Figure 1.3: Two interacting activity systems as the minimal unit of analysis in CHAT (Engeström, 2001, p. 136). In this example, the model is used to conceptualize overlaps and discoordinations between pediatric clinics and hospitals in Finland (after Engeström, 2001).

Engeström (2001) applies this model to examine the gaps, overlaps and discoordinations between a pediatric clinic and hospital oriented around the same object of activity - children moving between primary care and the hospital (Figure 1.3, Object 1). However, features of the individual system, such as the tools they use, result in each system transforming these objects into somewhat different outcomes. In Engeström's example, pediatric clinics used analytic tools that focused on the specific needs of the patient while hospitals addressed the same problem by developing tools focused on the patient's diagnostic group (*care relationships vs. critical pathways*, "tools" in Figure 1.3). These differences in the diagnostic tools and procedures were developed in response to demands specific to each activity system. They helped produce *locally* meaningful ways of conceptualizing and treating patients (Figure 1.3, Object 2).

However, when patients moved from clinic to hospital or vice-versa, contradictions and problems with the application of these tools were thrown into relief. The resulting difficulties in turn motivated these institutions to collaborate in order to produce a new, common care plan for their patients (Figure 1.3, Object 3) that improved patient care and reduced the cost and difficulty of care provision.

When we apply this approach to the current study, we have an even more complex situation. First, we take as our focus of concern not a commonly used tool but a commonly useful activity system. Second, the U-C Links project studied in this thesis involves more than one university group. Finally, the PLA is itself but one in an ongoing series of after-school enrichment activities, with a history of its own. I return to these complexities when I outline the present project below in section 5.

4.2. Idioculture

While the conceptual tools provided by CHAT are a useful set of lenses through which to analyze activities of the sort represented by the PLA, their organization into a static geometric triangle does not provide ready tools for thinking about the dynamics and meanings of the interaction or the "feel" of the group activity in its context. To understand this aspect of the PLA I turned to the notion of idioculture, as proposed by Gary Alan Fine (1979) and incorporated into CHAT methodology by Cole (1996).

Using perhaps Fine's most famous example, the study of little league baseball teams, he characterized an idioculture in the following terms:

> A system of knowledge, beliefs, behaviors, and customs shared by members of an interacting group to which members can refer and employ as the basis of further interaction. Members recognize that they share experiences in common and these experiences can be referred to with the expectation that they will be understood by other members, and further can be employed to construct a social reality. The term, stressing the localized nature of culture, implies that it need not be part of a demographically distinct subgroup, but rather that it is a particularistic development of any group in the society. (Fine, 1979, p.734)

In the present circumstances, the notion of idioculture helps us highlight the ways in which *valued* behaviors and customs of the interacting groups functioned to enable the free flow of interaction that everybody agreed was important for arranging successful opportunities to learn and subsequent learning. Introducing the notion of culture in this manner also provides us with a way to think more broadly about the divides of school/after-school and formal/informal learning, and a means to connect these divides with the distinct cultural contributions that each of the participating institutions made to the activity.

4.3 Distributed Cognition

Another important analytic source in my work is the theoretical position referred to as Distributed Cognition (hereafter DC; Hollan, Hutchins, Kirsch, 2000; Hutchins, 1995). There are strong resemblances between DC and CHAT that make mutual borrowing among these viewpoints productive (Cole & Engeström, 1993; Halverson, 2002; Kaptelinin & Nardi, 2006;). Like CHAT, DC is an analytic framework that defines processes of thinking and learning on the basis of the functional relations among the elements that jointly participate in these processes (Hollan, Hutchins, Kirsch, 2000, p. 175). What distinguishes DC from traditional cognitive theories is the scope of the elements assumed to participate in cognition.

In addition, both approaches see mediational means not simply as facilitating or replacing thinking, but fundamentally shaping and transforming it. It follows that the human mind cannot be unconditionally bounded by the body but must be seen as distributed in these mediational means which are interconnected and which interconnect individual human actions in and as a part of the permeable, changing, events of life (Cole & Wertsch, 1996; Hutchins, 1995).

From a DC perspective cognitive media can range from neurons in the brain to the collaborative work performed by pilots in the cockpit of a commercial airliner. DC research has historically focused on the latter: analyses of cognition among adults in the social organization of technologically-driven work activities (e.g. team navigation on navy ships, air traffic control, human-computer interaction). Cognition is externalized for analysis in human activity because human communication constitutes the media through which a socially distributed cognitive system does its work (Hutchins & Palen, 1995).

DC's theoretical emphasis on distributed cognitive processes is reflected in a methodological focus on events. Since the cognitive properties of systems that are larger than an individual play out in the activity of the people in them, the cognitive ethnography that defines DC is an "event-centered ethnography" (Hollan, Hutchins, Kirsch, 2000). The concern here is not just in what people know, but in how they apply this knowledge to do what they do.

When applied to thinking about the PLA, DC proves useful as a means of understanding cognition as externalized in the social interaction that is visible to the naked eye. It adds to the toolkit provided by CHAT in that it gives us a compatible lens for looking at the micro-dynamics of interaction and methods of obtaining the relevant data.

5. Rising to the Concrete: Applying the Theoretical tools to Study the PLA

In the process of planning, designing, and implementing the PLA my colleagues and I sought to bring each of the three theoretical perspectives outlined above to bear on the research process.

5.1 The PLA and the "Community Partner" through a CHAT lens

My initial characterization of CHAT depicted two institutionally-based activity systems interacting in order to produce a common new tool. In his recent writings, Engeström (2001, 2008) has emphasized that often several interacting activity systems may be the appropriate, inclusive, unit of analysis. That is true of the case presented here.

To begin with, in the current project the institution understood as the "Community" in the U-C Links program is best conceived of as itself the product of an ongoing U-C Links collaboration between SDLC and LCHC. This activity system, called the Learning Lounge, was a collaboration between the staff, youth, and families of the SDLC, where program activities physically took place, and LCHC staff, researchers, and students. The Learning Lounge, schematically represented in Figure 1.4, was an activity that mixed the needs of SDLC for educational resources for its local youth and LCHC's need to conduct research and educate undergraduates.

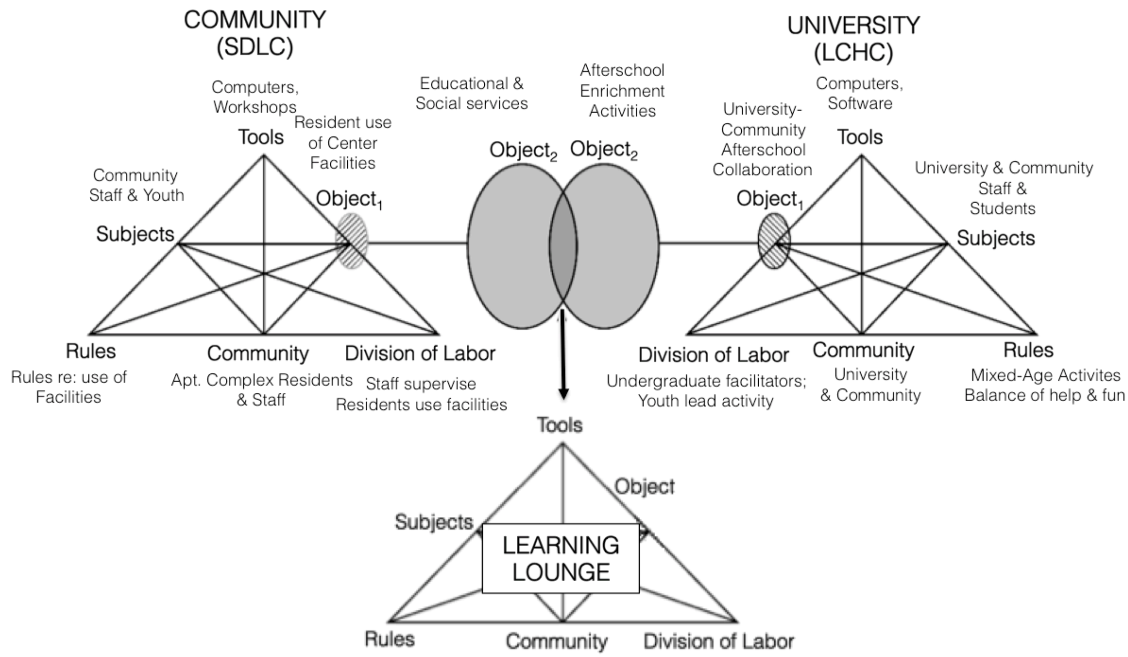

Figure 1.4: A CHAT representation the Learning Lounge as an activity system emergent in the collaboration between SDLC and LCHC.

LCHC came to the project with a history of designing, implementing, and studying after-school learning activities through U-C Links type collaborations. Over time, it had elaborated a variety of methods for adapting CHAT principles to developing such collaboratively constructed activities. These included, for example, the use of specialized tools (computers, educational software, the Web), the emergence of *rules* for how to engage in activities ("Give as little help as you can, but enough so that both you and the child have a good time"), and a *division of labor* (wherever possible youth lead, undergraduates facilitate, community and university staff supervise youth and undergraduates; Cole & the Distributed Literacy Consortium, 2006).

At the same time, the SDLC had a history of providing social and educational services to all of the apartment complex residents, not just the youth. This circumstance meant that the space and activities had to meet the needs of both the local youth and adults. For example, time on computers (*tools*) had to be organized (*rules*) in a non-conflictual way to allow adults to work on job searches and for youth to do their schoolwork.

Clearly a wide variety of needs in the Learning Lounge had to be accommodated in order for the two systems to come together productively. LCHC took the initial tack of simply joining in and helping Ms. Teresa, the site coordinator, and the SDLC youth with whatever it was that they were doing. In time, as we became familiar with life at the center and "the center" became familiar with LCHC, what emerged was a reflexive way of collaborating on the design of activities that privileged and built on the already established practices at the site. The result was an ecology of activities that included ones already in existence at SDLC and new, collaboratively created (LCHC-SDLC) activities.

5.2. The PLA as Idiocultural Hybrid

The ecology of activities that emerged in the Learning Lounge illustrates the classic circumstances for the emergence of an idioculture. Following Fine (1979), the Learning Lounge was and remains a "particularistic development" of an "interacting group" that came to share a "system of knowledge, beliefs, behaviors, and customs" through which they collectively constructed a “social reality.” Furthermore, the Learning Lounge was a *hybrid* of idiocultures characterized by “knowledge, beliefs, behaviors, and customs” that originally were specific to SDLC and LCHC. I convey this idea in Figure 1.4 above by modifying the model of interacting activity systems to reflect the fact that in a U-C Links program like the Learning Lounge, the focal object organizing the interaction between university and community is not just a tool (as in Engeström’s pediatric healthcare example, Figure 1.3) but an activity system (“Learning Lounge” triangle, Figure 1.4).

Turning to the focal activity examined in this dissertation, the PLA can be understood as the object of joint activity between the Learning Lounge and the university group of physicist-educators in Colorado responsible for the curriculum and instruction of the PLA (Figure 1.5). In other words, the PLA was an idiocultural hybrid of the Learning Lounge and Colorado.

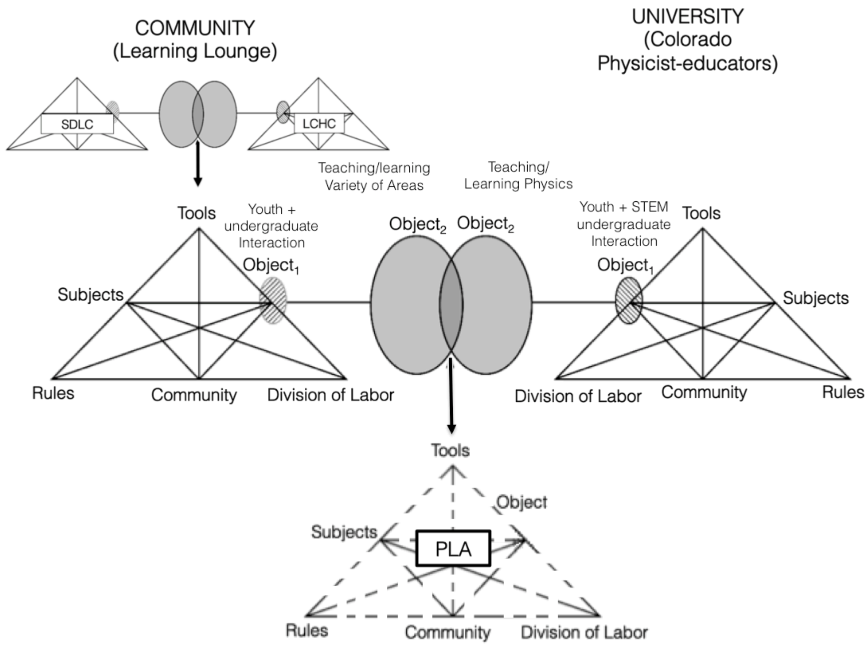

Figure 1.5: The model of two interacting activity systems adapted to show the development of the PLA. The PLA is a hybrid activity system constituted by a mixture of the various mediational relationships and objects of activity that make up the Learning Lounge and the Colorado University. Note that the Learning Lounge itself is a hybrid of the Community Center and LCHC activity systems.

5.3 The PLA as Socially Distributed Functional System

Both the concepts of idioculture and activity are powerful tools for understanding the culture and history of the PLA as a teaching/learning environment. In combination with these ideas, a distributed cognition approach helps us makes sense of participant interactions over the course of the PLA that made it a teaching/learning activity.

In defining culturally mediated interaction as cognition, distributed cognition sensitizes us to the importance in analyses of teaching/learning activities of studying how people use technologies to coordinate with one another and the environment. A key implication of treating the network of people-technology-environment as a socially distributed functional system is that communicative behaviors are considered evidence of cognitive processing. From this perspective thinking is observable in the propagation of information across the media constituting the system, and learning is understood as the system's adaptive reorganization (Hutchins, 1995).

Distributed cognition's focus on the role of technological mediation in coordinating distributed systems is especially relevant to the PLA. The PLA centrally depends on digital technologies for its organization and for its claims to efficacy as an educational activity. A distributed analysis, for example, throws into relief the ways in which the technologies used in the PLA both constrained and afforded particular ways of interpreting the physics material, and, consequently, constrained and afforded ways in which participants interpreted one another.

6. The PLA as a Formal/Informal Hybrid

The PLA was implemented in the Learning Lounge as an example of the kind of telementoring activity that provides full access to the teaching/learning resources believed to promote *opportunities to learn*. My contention is that the notion of access employed in this literature is insufficient. The problem is not solely about the ready and reliable availability of teaching/learning resources. We must also consider the crucial question of how these resources are successfully coordinated and organized to accomplish learning. In particular we need to examine the ways in which the Community institution in the U-C Links collaboration shapes the circumstances in which access to these potential resources can be realized.

How teaching/learning resources are organized depends in part on the knowledge, beliefs and customs that each participating institution draws on to implement educational activities. My focus will be on valued forms of knowledge, beliefs and customs that members of the Learning Lounge and members of the Colorado group deployed as they strove, each in their own way, to organize rich opportunities to learn for the local youth.

Viewed in this way, the PLA project can usefully be conceived as the interaction of two activity systems, each with its own idioculture. The Colorado group was composed primarily of university personnel who were both physicists and teachers. The group's idioculture valued certain "ways of knowing" focused on the disciplinary domain of physics. These ways of knowing and the practices through which they are ordinarily taught embody the very cultural values that divide formal and informal education as we discussed earlier. The Colorado group comes to the interaction, embodying what is ordinarily referred to as formal education.

By contrast, as noted at the beginning of this chapter, after-school is traditionally understood as a site of informal teaching/learning. The Learning Lounge is a mixture of formal and informal educational beliefs and practices. When children are required to do math homework, they are asked to work on their own using the materials provided by the school. Only after they have completed as much of their homework as they can, are the youth supposed to ask the undergraduates at the center for help. When that help begins, formal and informal start to intertwine as ways of organizing the children's learning opportunities. The undergraduates, for example, think up inventive new activities that the children will enjoy and that involve them in some way in the academic world that awaits them the next morning.

After homework is done, the informal rules. This is “enrichment time” when the tasks devised by the undergraduates and the researchers to create opportunities to learn are tried out. For the activities to work, the kids must be interested, otherwise the accepted norm is that the kids can walk away. For the kids to be interested, there needs to be some connection between them and the activity. This is why another norm is that the activities must be driven and shaped by significant input from the kids.

These beliefs, values, norms, and context, the idioculture of the Learning Lounge, contrast with formal, prescribed approaches, in the freedom that the children have to determine both the means and the goals of the activities. This norm is the heart of informal teaching/learning.

The core problem framing my analyses is how to understand the mechanisms by which the two forms of education embodied in the overall PLA system - formal/schooled/prescribed vs. the informal/functional/negotiable and everyday activity-bound - managed to resolve the inevitable tensions and conflicts that mixing of these two idiocultures entails. Moreover, this resolution had to be accomplished in ways that secured the continued *voluntary* participation of everyone involved. To explore these problems I was guided in my analyses by the following questions:

What local mediational strategies emerge when formal knowledge and corresponding pedagogies are imported into the idioculture of after-school settings, with their "not school" practices and their informal pedagogies?

Are such mediational strategies successful in their attempt to produce opportunities to learn?

What are the implications for efforts to design and implement technologically-driven after-school science learning activities?

During the course of my analysis I came to realize that the formal/informal distinction as it played out in the activity we organized maps on to two systems of knowing, two distinct *epistemes*. These epistemes differed along lines similar to those used by Livingstone (2006) to characterize the formal and informal. On the one hand, there was a *logocentric* episteme characterized by an emphasis on approaches to problem solving that were rational, documentable, verbally expressible and broadly applicable. On the other hand, there was a *pragmatic* episteme characterized by an emphasis on problem solving that was improvised, functionally relevant, situated, and embodied through action.

In the analyses that follow, I draw on ideas from CHAT, distributed cognition, and idioculture research to trace the role of these mediational strategies in how the PLA was changed over time to resolve the tensions produced by the coming together of the formal/

logocentric and informal/pragmatic epistemes. I will devote relatively little attention to the study of changes that occurred within each of the organizations that collaborated to create the PLA except in cases where such changes are directly linkable to changes that occurred within the PLA. Rather, I will focus on the internal dynamics of the activity system/idioculture that grew out of their interaction, the PLA, introducing relevant specific CHAT concepts as they arise. My attention will be focused not only on the digital technologies that mediated between the two activity systems but especially on my role as local mediator, "native" to some degree to both of the activity systems involved.

CHAPTER 2: Methodology

1. Introduction

In this chapter I outline my methodology for implementing, documenting, and analyzing the PLA. I begin by describing the overall structure of the institutional collaboration that produced the PLA, including the key participants that feature prominently in my analyses. Following this I outline the basic design of the PLA and how the activity actually unfolded. As part of this discussion I describe the curriculum and the technologies used in the activity. The second half of the chapter is devoted to a discussion of the logic and methods of analysis, as well as the forms of documentation gathered.

2. Overall Structure of Collaboration: Participation at a Distance

In this section I describe the community and university stakeholders who developed and implemented the project, as well as the key participants.

2.1 The Research Collaborative

The research collaborative responsible for the design and implementation of the PLA consisted of three university research groups and one community institution. These were:

1. The Engineering Education Group (EEG) at a Massachusetts University.[1]
2. The Physics Education Group (PEG) at a Colorado university.
3. My home laboratory, the Laboratory of Comparative Human Cognition (LCHC), at the University of California, San Diego (UCSD).
4. The San Diego Learning Center (SDLC), a community after-school center.

The origins of the collaborative can be traced to the summer of 2007 when faculty and students at LCHC, PEG and EEG came together to discuss and pilot test a suite of new digital technologies for supporting STEM education in after-school settings. This work was done in anticipation of a joint effort among the members of the collaborative to prepare a grant proposal. A component of the proposed research involved assessing the learning of after-school youth who were introduced to a suite of programming-focused software applications and related activities. One of the activities that the collaborative proposed was the PLA.

The members of the collaborative brought to the table a variety of research goals and expertise. Our partners at EEG had developed a software application for creating stop motion animation movies. They were studying its use in classrooms as a tool for helping students learn STEM content. PEG had pioneered STEM education community outreach projects in the Colorado after-school centers. We at LCHC engaged in university-community after-school collaborations in Southern California. Our efforts and those of

[1] With the exception of my own name and that of my home laboratory, the names of participants and participating institutions have been changed.

our PEG partners were motivated in part by an interest in providing access to enriching educational activities for youth in the community, while simultaneously doing the same for the university students who visited the after-school centers as part of their participation in PEG and LCHC-run practicum courses.

The collaborative viewed the PLA as an arena for exploring a variety of research questions. Taken together, these questions connect to the problem discussed in the beginning of the dissertation of how to organize resources in such a way as to produce authentic opportunities to learn. For our PEG partners, the PLA afforded an opportunity to study the effectiveness of their model of university-community after school physics education in a distance learning context. For our partners at EGG, the PLA was a context in which to study how the youth at SDLC adopted and adapted their stop action movie software to learn physics. Lastly, we at LCHC were interested in studying how this ensemble of resources might create an engaging learning activity for the local youth and the university students.

The division of labor for the project was as follows. The EGG contributed software and hardware along with technical support. PEG took the lead in developing the curriculum and providing the instructors to implement it. This involved incorporating EEG software and hardware along with physics simulation software provided by the PEG group. LCHC graduate students and undergraduate students participating in the practicum course provided technical and social support at the local level. The space for conducting this activity was provided by the SDLC.

2.2 Focal Participants

In the following section I provide brief and relevant background on members of the research collaborative and organizations who figure prominently in my observations and analyses. For each person introduced, I provide brief biographies that include only those details necessary for understanding their relationship to the PLA.

2.2.1 SDLC Participant: Daisy

Daisy[2] is the focal PLA participant followed in this dissertation. All of the analyses presented here are based on observations of Daisy's year-long participation in the project. At the time that she joined the PLA, she was just beginning her sophomore year in high school. I recruited her because she had failed her freshman physics class (and then passed with a C in summer school), and I believed she might benefit from and enjoy engaging with physics in this considerably different way. I had interacted with Daisy over the summer prior to the beginning of the project, and I found her friendly and approachable. She also showed an eagerness to participate in many of the projects that UCSD students organized in the Learning Lounge. For me, all of this was an indication that Daisy would be someone who could be relied upon to show up.

The day I recruited her, Daisy informed me that she aspired to be a robotics engineer. In fifth grade she had joined a Lego Mindstorms in-school robotics team and

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[2] All names of participants are pseudonyms.

had remained part of the team through her middle school years. She also expressed enthusiasm for learning about math and science, verbally and in her responses to science attitudes questionnaires.[3]

Unfortunately, Daisy's difficulties with science did not end her freshman year. During her sophomore year she failed geometry. She continued to struggle with math and science the rest of her time in high school, failing algebra and chemistry. As we will see in subsequent chapters, Daisy also had difficulty understanding and talking about the physics materials introduced in the PLA.

2.2.2 SDLC Participant: Aisha

Aisha was a fourth grader who Daisy recruited to participate in the PLA. She was and is among the most outgoing and confident of the SDLC youth. I later argue that Aisha's inclusion in the PLA led to productive changes that were consequential in creating authentic opportunities to learn.

Aisha is a central subject in my analyses in Chapter Four.

2.2.3 PEG Participant: Mary

Mary, a Ph.D. research associate, was the director of PEG's University-Community Coalition for Informal Science Education (UCISE). In this role, Mary

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[3] The questionnaires were administered pre & post as part of the assessments that the Colorado team had prepared for their research.

traveled to various after-school centers affiliated with UCISE to supervise and at times conduct implementation of science learning activities.

In the PLA Mary had multiple roles. She was the supervisor of the PLA project. In this role she developed and revised the curriculum used to structure the lessons and exercises of the PLA. Over the course of the project Mary and I held planning sessions in which we assessed the learning of the SDLC student participants and discussed changes to the activity in order to ensure that the students would continue to learn.

Mary was also responsible for recruiting and training the university physics students for the PLA telementoring sessions. At times, she led instruction in some of the telementoring sessions that took place in the beginning stages of the project. In her role as trainer, Mary was also present during the trial run of telementoring activities (Fall 2007) and the first series of PLA telementoring sessions that took place in the main PLA study (Fall 2008). In these sessions she either guided the university students as they attempted to work through the curriculum with the SDLC youth, or she performed the instruction herself.

Mary is a central subject in my analyses in Chapter Four.

2.2.4 PEG Participant: Tom

Tom was the primary PLA instructor. He joined the PLA research collaborative mid-way through the implementation of the PLA, in January of 2009. At the time he was in his second year as a physics doctoral student. Before joining the PLA, Tom had an extensive history of one-on-one tutoring. He tutored AP physics in high school, and as an undergraduate physics major he tutored high school and college students in physics and math. As a graduate student he had one year of experience as a teaching assistant. At the beginning of his second year he took one of the after-school practicum courses offered by PEG. Tom chose to do his fieldwork at the after-school center in Colorado where the curriculum used in the PLA was concurrently being tested. Throughout the semester Tom visited the site once a week for two to three hours to engage in teaching and fieldwork. He described the class as “probably the most important educational experience I've had w/respect to teaching,” and as having “had a very large impact on my thoughts on teaching,” (email correspondence, 6/28/11). The following semester, UCISE secured outside funding to hire a fixed instructor for the PLA. The course instructor recommended Tom, who was hired to work on the project from January to May of 2009. When the funding ended, Tom volunteered to continue being the PLA instructor without pay until the project ended in the fall of 2009.

Tom is a central subject in my analyses in Chapter Three.

2.2.5 LCHC Participant: Robert

My initial role in the PLA was that of ethnographer and supervisor/organizer of the PLA at SDLC. Over the course of the project I also took on the role of the sole local facilitator (Section 5.1, this chapter). As noted, I worked in the Learning Lounge for a year-and-a-half prior to the PLA project’s initiation.

With this brief characterization of the main participants in place, I now turn to describe the overall sequence of activities in which these participants engaged and the methods of documentation that served as my primary data.

3. The PLA: Chronology, curriculum, and technologies

In this and in the following three sections I describe the chronology of the PLA and the design elements of the activity as they were conceived in the initial stages of the project.

The original plan was to implement a curriculum on electronic circuits that could be completed in one academic year (three, ten-week quarters). This curriculum was divided into six topic sequences. Against expectations, we only completed the first and second sequences. Sequence 1 - *Circuit Building* - was covered in the fall quarter of 2008, and Sequence 2 - *Conductivity* - was covered in the winter and part of the spring quarter of 2009. In late May of 2009 the curriculum was modified to provide Daisy with a real life situation in which to apply what they had been learning in the curriculum to that point. I call this phase Sequence 3 - *House Wiring Project.* This sequence involved Daisy building a small scale model house and using the circuit construction materials from Sequences 1 and 2 to wire the house so that small light bulbs placed in each of the house's rooms could be lit independently using multiple switches and a single battery.

All told, there were three phases to the portion of the PLA project that is examined in this dissertation: Phase 1 (fall of 2008) covering the content in Sequence 1 (exploring battery-wire-light bulb circuits); Phase 2 (winter and spring of 2009) covering the content of Sequence 2 (conductive materials); and Phase 3 (spring and summer of 2009), the house wiring sequence that covered content from topic sequences one to four of the original curriculum (Figure 2.1).

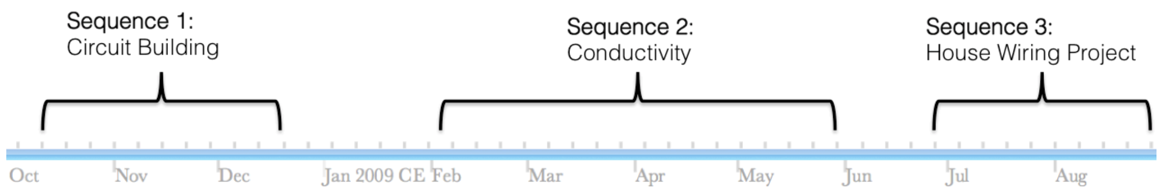

Figure 2.1: Timeline of the PLA showing the actual schedule of completion for the topic sequences covered.

3.1 Curriculum

The curriculum used for the activity was adapted by our Colorado partners from a physics telementoring activity that we implemented prior to the portion of the PLA project examined in this dissertation. In this telementoring activity – through a combination of on-line, video chat-mediated interactions and off-line tasks that complemented the on-line activities – an SDLC fifth grader learned to use stop action movie software to accurately describe the concepts of constant speed and acceleration (see Mayhew & Finkelstein, 2008). Encouraged by this success, our Colorado partners decided to run another series of telementoring activities. This time they developed the aforementioned curriculum on electronic circuits, which was created by Mary based on a related set of curricula shown to be successful in classroom settings (Otero & Gray, 2008). Activities were divided into six consecutive topic sequences, each of which built on the information and exercises covered in prior sequences:

1. Circuit Building
2. Conductivity
3. Energy
4. Series and Parallel Circuits
5. Current
6. Ohm's Law

Appendix B includes complete versions of the curricular worksheets used for the first two topic sequences.

3.2 PLA phases and sessions

Tasks in each topic sequence were sub-divided into three consecutive phases:

1. A tele-mediated *instructional phase* in which the SDLC students together with a local UCSD undergraduate facilitator would be introduced to the sequence-specific physics content via video chat.
2. A local *video production phase* in which the SDLC students together with a local UCSD undergraduate facilitator would use the stop motion animation software to create explanatory animated videos about the content. Once completed, these videos would be emailed to the instructor in Colorado for review.

3. A tele-mediated *group discussion phase* in which the instructor would use video chat to discuss the videos with the SDLC students in an effort to assess and explore what the youth had learned, including clarifying whatever preconceptions students may have had about the material.

In later chapters it will be important to distinguish between tele-mediated activities involving the participation of our Colorado partners (i.e., activities in the instructional and group discussion phases) and those taking place locally at SDLC involving only members of the Learning Lounge (i.e., activities in the video production phase). For this reason, I refer to activities that took place within the instructional and group discussion phases collectively as *telementoring sessions,* and those that took place in the video production phase as *local sessions*.[4]

In addition to the telementoring and local sessions, there were also *planning sessions* between relevant LCHC and Colorado personnel. The majority of these sessions, which were scheduled as the need arose, only involved me and Mary. The focus of these sessions was, among other things, assessing student progress and discussing how to modify the activity to help facilitate this progress.

Figure 2.2 summarizes the organization of phases in each topic sequence, the types of sessions held in each phase, and the participants assumed to be present in each session.

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[4] With only a few exceptions, discussions in this dissertation about telemediated interactions concern telemediated activities in the instructional phase. This is why I reserve the term telementoring sessions for these activities (dropping "instructional" to reduce the length of the term) and group telementoring sessions for activities in the group discussion phase.

A total of 56 sessions were held over the course of the PLA project. Of these, 33 were local sessions, 13 were telementoring sessions, and 10 were planning sessions.

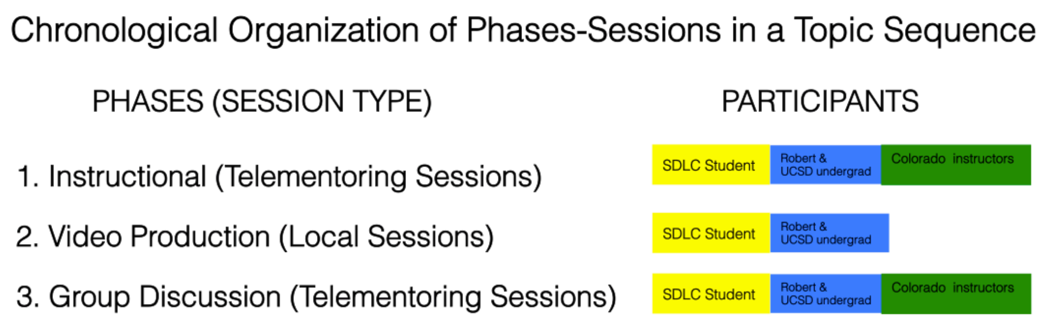


Figure 2.2: Organization of activities during one PLA topic sequence.

In the original design, the SDLC student would participate first in a weekly telementoring session followed one or two days later by a local session. During the telementoring session the student would be introduced to the physics content, work on exercises to promote discussion and thinking about this content, and discuss projects that the SDLC student would work on during the local sessions. During the telementoring sessions the plan was to have a UCSD social science undergraduate present to act as a local facilitator. I would be there solely to document the activity and to intervene when absolutely necessary. In the local sessions the SDLC student would collaborate with a different UCSD social science undergraduate to use the stop action software to make the explanatory videos.

3.3 Digital Technologies for the PLA

In the following sub-sections I describe two software applications that were field tested as part of the PLA project: the Engineering Educations Group's *Stop Action Movie Software* and the Physics Education Group's *Circuit Construction Kit*. I also briefly discuss our use of video chat — the primary means of communication in the instructional and group discussion phases — with a focus on consequential interactional constraints that emerged from this use.

3.3.1 Stop Action Movie Software

The *Stop Action Movie* software (also referred to as SAM) used in the PLA was provided by our partners in the Engineering Education Group (Figure 2.3, www.samanimation.com). The rationale for using SAM as an educational tool was grounded in the idea that learning is facilitated when content is explored through multiple modes of expression (Church, Gravel, & Rogers, 2007). As a movie making tool SAM allows users to create dynamic visual representations of science concepts, models, and practices that can be easily reviewed, discussed, and revised. Furthermore, as the software's designers argue, the process and products of movie making give students a sense of ownership over their learning materials and over their learning (*ibid.)*.

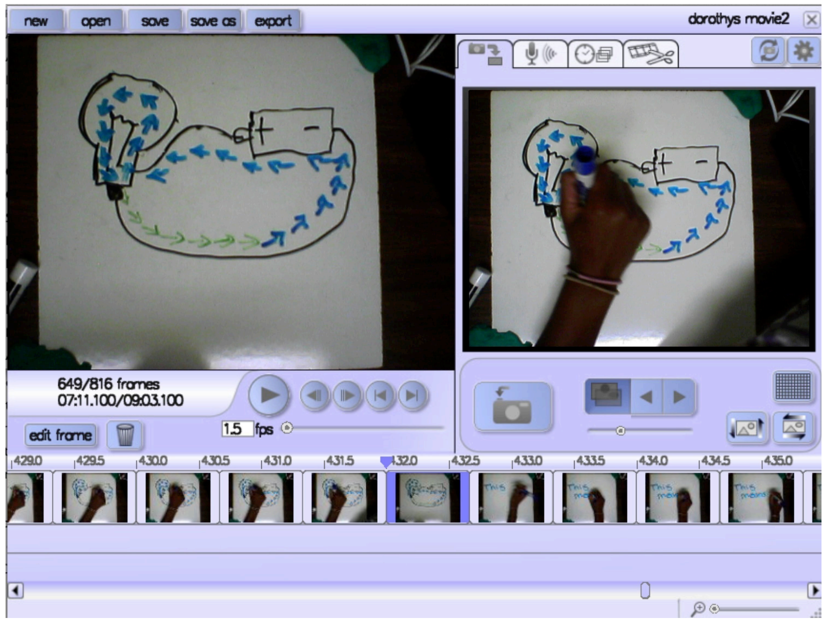


Figure 2.3: A screen capture of the interface for the stop action movie software used in the PLA. The window on the right displays the feed from the webcam used to take snapshots of the material being used for the video. The screen on the left displays the image of the last snapshot taken. The series of thumbnails running across the bottom of the interface constitute a timeline of the snapshots taken so far in the production of the video.

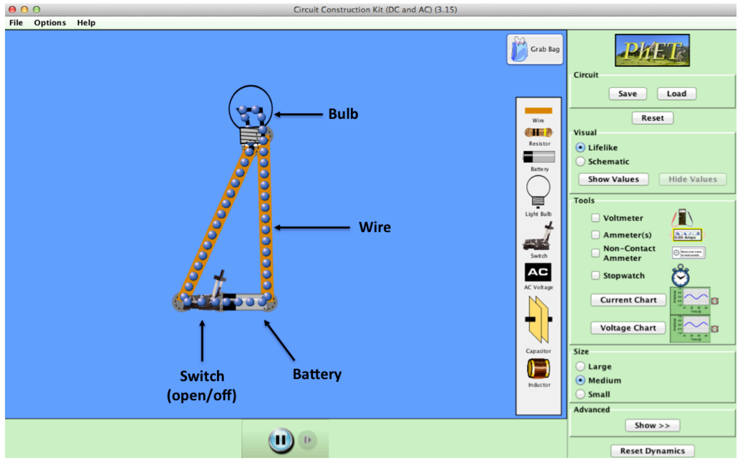
3.3.2 Circuit Construction Simulator

A second piece of software incorporated into the activity was the *Circuit Construction Simulator* (CCS). This application, however, was added only as a supplement and there was no initial research interest in examining its use in the PLA. The CCS is software for modeling the construction and activity of simple electronic circuits. It was developed by PEG researchers as one of over 50 Java-based applications in a suite of science simulations in PEG's Physics Education Technology (PhET) project (http://phet.colorado.edu).

The CCS interface resembles an open workspace where users can select, manipulate, and animate a variety of components for building simple circuits in real time (e.g., light bulbs, batteries, copper wire, resistors; see Figure 2.4). Not only can each component be manipulated to establish its physical orientation in the circuit, but each can also be adjusted to reflect desired configurations with respect to parameters, such as voltage, resistance, and current. The flow and conservation of the current is depicted by the movement of electrons (represented as blue balls in color reproductions, grey-white balls in black and white reproductions) through the different materials that users join together to construct a complete circuit. Users have the option of turning the simulator on/off so that they can inspect their circuits when the electrons are flowing (on) or when they are in a state of suspended animation (off).

A technical note about the images of the CCS included in Chapter Three. When the CCS was used in the day-to-day activities in the PLA, we used a display setting that depicted electrons in the wires, batteries, switches, and bulbs as tiny blue balls (Figure 2.4 A). The images of the CCS used in Chapter Three are of the CCS with this display setting turned off (Figure 2.4, B). I chose this latter version of the images because it allows for easier identification of the circuit components, making reading of the analyses in Chapter Three much easier.

A



B

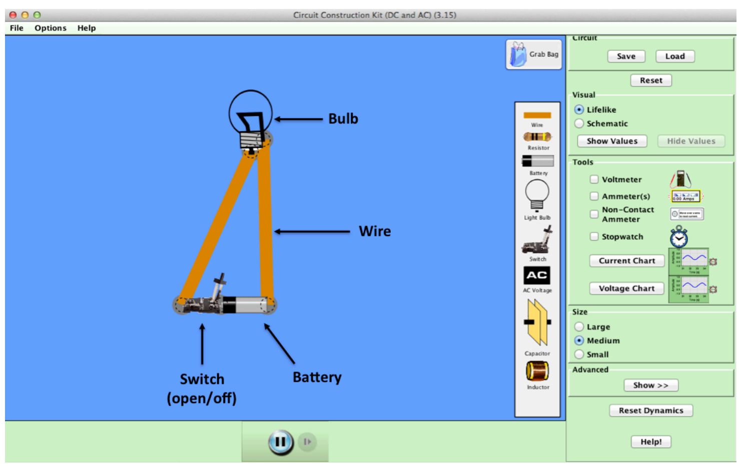


Figure 2.4: (A) CCS interface with electron display setting activated. Blue balls represent electrons. (B) CCS interface displaying the image in (A) with the electron display setting de-activated.

3.3.3 Video Chat

Free desktop video chat software was used to conduct the telementoring sessions. Figure 2.5 provides a general description of the technical infrastructure for implementing the sessions.

Figure 2.5: Description of telementoring technical infrastructure in the PLA. The largest image depicts a moment taken from a telementoring session as seen in the room at the San Diego Learning Center where the PLA activities took place. (A) Daisy. (B) Robert. (C-1) Laptop used to run the CCS. (C-2) Screen capture of the video feed from SDLC as seen by our partners in Colorado. (D-1) Monitor used to display the video feed from Colorado. (D-2) A screen capture of the video feed from Colorado, as seen by Robert and Daisy. Tom, the instructor from Colorado, is shown. (E) Webcam (affixed to a mini-tripod) used to provide the video feed from SDLC to Colorado.

A key constraint that will figure prominently in my analyses concerns our limitations in having only one webcam to provide video feed of activities at the SDLC. The position of the camera determined what and how much was perceptually available to our partners in Colorado. Furthermore, how the camera was positioned was in turn constrained by the nature of the activity. In the telementoring sessions, the majority of the time was dedicated to three kinds of tasks: 1) using circuit building materials to build battery/bulb circuits, 2) using the CCS to do the same, or 3) using small, personal dry erase boards to draw circuits and circuit building materials. Accordingly, the SDLC webcam was trained on those parts of the room where these activities unfolded.

My analyses in Chapter Three focus on activities involving the CCS. For these activities, the webcam was trained on the computer monitor displaying the CCS interface 85 − 90% of the time (e.g. C-2, Figure 2.5). As a result, many non-verbal cues important for human communication (e.g., body positioning, facial expressions) were unavailable to our partners in Colorado. At the same time, Daisy and I were at times insensitive to the visual conduct of our partners in Colorado. This is a common phenomenon in video-mediated communication; people tend to distance themselves from the moment-to-moment demands of their interlocutors while simultaneously preserving mutual availability and coordinating local tasks (Heath & Luff, 1993). In the specific case analyzed in Chapter Three, Daisy and I rarely attended to the visual aspects of the video feed from Colorado because the circuit building (actual or virtual) activities that we were engaged in demanded our visual attention.

4. Logic of Analysis

In line with Cultural Historical Activity Theory (CHAT) principles, the overall logic that I followed in my analyses was to treat the PLA as an activity system and trace its development with respect to how it transformed objects of activity into outcomes. That is, I focused on how teaching/learning resources were organized in the PLA such that they produced successful teaching/learning events. I followed the methodological injunction that: 1) in order to understand behavior we must understand the history of that behavior (Wertsch, 1985), and 2) in order to understand the history of behavior we have to understand the histories of the people involved and the means used to mediate those behaviors. To this end I developed the following sequence of analyses:

1. *Event selection*. I defined an event as a successful learning event when: 1) it was clear that the SDLC student understood the ideas being taught or could independently perform the target skill (e.g., building a circuit), and 2) the instructor and the local facilitator showed agreement that the student had learned. I restricted my review to telementoring sessions in part because these were the only kind of sessions in which all three relevant participants were present. At the same time, I focused on telementoring sessions because analyses of these sessions would address questions discussed in Chapter 1 about the feasibility of telementoring programs to provide opportunities to learn after school. Of the 46 total PLA sessions, 13 were videoconferencing sessions.

I identified three videoconferencing sessions in which all three key participants showed signs of satisfaction that physics learning had taken place (3/4/09, 3/11/09, and

8/19/09). The 8/19/09 session stood out for a number of reasons. First, it was the only session of the three in which the learning that unfolded involved an accomplishment that was necessary for meeting an overarching goal for the activity. Second, the end of the 8/19/09 session was unusually positive in collective affect. Both Tom and I, and to an extent, Daisy, did not expect Daisy to accomplish what she accomplished in this session – building a parallel circuit – so we were especially pleased when she succeeded. Furthermore, this success occurred two sessions after we had radically restructured the PLA from an activity focused on using stop motion animation to one centered on wiring and lighting a model scale home. In the context of the house wiring sequence (see Section 3 above) Daisy's having learned to build a parallel circuit represented a major breakthrough, as this was the key skill she needed in order to properly wire her model home. All of these aspects of the session clearly marked it as a success. For this reason I selected this session (hereafter the *parallel circuit session*) for further analysis to identify and characterize any forms of adaptive mediation that may have emerged and contributed to this success.

2. *Interactional analysis*. Having identified a successful event in which there was evidence of learning, I drew upon concepts and methods from distributed cognition, idioculture research, and CHAT (Section 5 below). I examined participant interactions in the selected event not only for moments of success, but for instances of interpersonal conflict, frustration, and/or confusion occurring prior to achieving success. My reasoning was that these prior interactions that called for resolution of interactional trouble would

make visible the mediational strategies that the participants used as they attempted to complete the task.

This strategy led to two important conclusions that shaped my subsequent analyses. First, instances of tension in the selected session could be traced to differences among participants in how they came to know and what constituted authentic knowing. It is here that I first began to conceive of the *logocentric* and *pragmatic* epistemes as a pervasive source of conflict in the PLA. Second, I identified three recurring mediational strategies that participants deployed in order to resolve epistemic tensions: *translation*, *backchanneling*, and *tool-use mediation*.

3. *Category-based, retrospective analysis*. Using the three mediational strategies identified in the interactional analyses of the successful learning session, I conducted a retrospective analysis of sessions leading up to the parallel circuit session in order to trace a developmental history of the mediational strategies and their relation to learning. The idea was to write a cultural history of these mediational strategies in order to better understand both the contradictions inherent in mixing formal/logocentric and informal/ pragmatic forms of physics instruction, and the means for addressing these contradictions in ways that promote authentic opportunities to learn.

5. Conceptual Categories Guiding Analysis

To perform the interactional and retrospective analyses described above, I drew on concepts and methods used in Distributed Cognition, CHAT, and idiocultural analyses.

1. *Participation Frameworks and Interactional Stances.* A central concern of distributed analyses is the characterization of the ways in which people use their bodies and material environments to coordinate with one another. From linguistic anthropology I borrow the concepts of participation frameworks and interactional stances (Goodwin, 2007a) as tools for performing this characterization. Briefly, as participants communicate they construct stances that signal their orientation to an interactively constructed participation framework. They also signal their expectations of co-participants' orientations to this activity. What these concepts offer is a way of describing the different epistemic orientations interlocutors have to a joint activity including *instrumental*, *epistemic, affective, moral,* and *cooperative* stances (Goodwin, 2007a). These orientations, as reflections of what and how people know, can be linked to the formal and the informal by way of the knowledge traditions described in the introduction (rational/scientific; situational/practical, Livingstone, 2006).

2. *Properties of mediational means.* Wertsch (1998) describedes properties of mediational means that are useful for understanding the adaptive functions of cultural mediation. In my interactional and retrospective analyses I focus in particular on the fact that

mediational means are culturally and historically situated; capable of both constraining and enabling action; and capable of supporting a multiplicity of goals.

3. *Mediational Strategies.* I combine CHAT's notion of mediation with the idea of idioculture to distinguish forms of mediation that made sense locally in the context of the Learning Lounge. This allows me to distinguish between Colorado's generally formal approach and the Learning Lounge's informal approach, and helps me highlight those locally successful strategies for adapting to the tensions and contradictions of combining the formal and the informal.

4. Structure of activity. CHAT posits inherent tension and contradictions in the structure of activity within and between the mediational relationships that constitute activity, as well as between activity systems. In this way CHAT serves as a tool for mapping events in activity over time that are potentially disruptive and at the same time transformative of activity.

6. Methods of Analysis

The research presented in this dissertation is based on a *cognitive ethnography* (Hutchins, 1995) of the PLA in which I occupied the role of *observant participant* (Brewer, 2000; Erickson, 1992).

6.1 Observant Participation

A core methodological strategy adopted by CHAT scholars is that of co-creating with others the activities that produce the phenomena of interest (Cole, 1996). The reasoning behind this is that we are best positioned to understand a phenomenon if we are part of the process that produces it. That is, *observant participation* takes place when a researcher arranges to become an instrumental part of the activity so that she can experience what it is like to become a functional aspect of the system and to actively co-construct the activity of interest (Engeström, 2008).

The more common form of participatory data gathering, *participant observation*, involves a researcher gaining entry into a community in order to take part in its day-to-day activities for the purpose of studying aspects of the community's social life (McKechnie, 2008). Observant participation, on the other hand, involves observation from the perspective of an existing role in a community or activity of which the researcher is already a member (Brewer, 2000; Erickson, 1992). In this way, the observant participant, compared to the participant observer, has a privileged viewpoint into the community of practice whose activities are under study (Rosero, Lecusay, & Cole, 2011).

As noted, I occupied both a community and a university role in the PLA. On the one hand, I was a member of the Learning Lounge (the community). At the time that the PLA project was initiated, the SDLC-LCHC collaboration (i.e., the Learning Lounge) had been in place for more than a year and a half. During this time I had been involved in all manner of activities related Learning Lounge life. These activities included working directly with SDLC youth, working with graduates and undergraduates who were teaching and conducting research, serving as a teaching assistant for the practicum course, and working with SDLC and LCHC staff to supervise and organize both special and routine Learning Lounge activities.

On the other hand, I was a member of the PLA research collaborative (the university). With the exception of developing and teaching the PLA curriculum, I collaborated with members of the Colorado group at every stage of the design and implementation of the PLA. Furthermore in my role as the local facilitator, I was the sole mediator between the Learning Lounge and Colorado and was the only person consistently present at every PLA session.

It is the idiocultures of the Colorado group and the Learning Lounge that are of central importance for addressing the core dissertation questions about the adaptive changes that emerged from combining formal and informal modes of teaching/learning in the PLA. As a member of the Learning Lounge and the PLA research collaborative I had feet in both worlds. This gave me a unique perspective on the PLA.

6.2 Cognitive Ethnography

The data examined in this dissertation was collected through a cognitive ethnography (Hollan, Hutchins, & Kirsh, 2000) of the PLA project. Cognitive ethnography differs from and expands on traditional ethnography in its emphasis on the documentation and analysis of the processual. The focus in traditional ethnography is on the meanings created by members of a cultural group, whereas cognitive ethnography focuses on how members create those meanings (Williams, 2006). To this end, cognitive ethnographers make extensive use of digital audio/video technologies in order to conduct fine-grained analyses of the moment-to-moment development of activity and its relationship to cultural-historical processes occurring at multiple time scales. At the same time, they draw on traditional ethnographic approaches — participant observation, interviews, artifact analysis — in order to establish frames for interpreting these analyses.

As a tool for studying situated activity, cognitive ethnography is suited to the present research. Understanding how people teach and learn under contradictory circumstances — as in activities like the PLA where the formal and informal are combined — requires studying how people adapt to these circumstances both when they directly confront them and in those moments when they anticipate these circumstances and make preemptive plans to resolve them. As I detail in the next section, in gathering my data I took care to document these events as well as to collect sufficient information about the cultural and historical context in which these events unfolded.

7. Documentation

Over the 42 weeks that the PLA project was implemented, I collected numerous and varied forms of documentation that afforded both microanalytic and cultural historical analyses of the PLA. At the same time, the multiplicity of documentation also allowed me to easily triangulate my data in those instances where triangulation was necessary. My primary means of documentation was digital audio/video. I also wrote field notes and video logs, generated transcripts of select sessions, and collected and analyzed participant produced media (including researcher emails and student-produced stop action movies). Additionally, I generated video logs of the video, transcripts of relevant sessions, and collected participant-produced media.

7.1 Audio and Video Documentation

Digital audio and video were collected of PLA instructional and planning sessions, as well as of presentations delivered to members of the research collaborative of ongoing PLA project work. The video data corpus encompasses the entire history of Daisy's participation in the PLA, including all the telementoring and local sessions in which she participated.

7.1.1 Videos of PLA sessions

Each PLA session was videotaped (with one exception) using two cameras. One MiniDV camera was mounted on a tripod and placed in the corner of the room in front of and to the left of the participants. This was done to capture a long shot of the face-to-face, whole body interaction among the participants. A second digital still camera with video recording capabilities was mounted on a miniature tripod and moved around as needed in order to capture close ups of actions that the participants were taking in the local space (e.g., capturing circuit building action on the work table, drawing, or to capture action on the computer monitor as the participants used the CCS or SAM). I distinguish footage taken from these two cameras by referring to the long shot footage as *face-to-face footage* and the close up footage as *close-up footage*.

During the telementoring sessions, my partners in Colorado used screen recording software (Pamela) to record video of the Skype video feed transmitted to their local computer monitor from TCLC. Technical difficulties with the screen recording software and/or the local hardware in Colorado prevented my partners in Colorado from capturing video from all of the telementoring sessions. Of the 13 telementoring sessions conducted, we obtained video of this kind for only eight sessions.

7.1.2 Audio

Audio recordings of all PLA instructional and planning sessions were collected. Audio was the primary means of documentation for the planning sessions, while it served primarily as a means of triangulation for the PLA instructional sessions. After each PLA instructional session I audio recorded myself verbally describing my observations and impressions of the events of the day, which served as a prompt for writing my own field notes and as a supplement for video logs.

7.2 Textual Documentation

Textual documentation of the project included field notes, logs and transcripts of audio/video documentation and interviews.

7.2.1 Field notes

I wrote field notes within 48 hours of the PLA instructional and planning sessions. These were incorporated with logs of video taken during these sessions in order to combine my impressions of events with the summary descriptions of what I observed in the video footage. Finally, I also drew on the corpus of field notes written by graduate and undergraduate students involved at the Learning Lounge as part of their independent research and/or participation in the field methods practicum courses, from the Spring of 2007 to the Winter of 2011. These field notes were archived on an LCHC server and were accessible via a searchable, password-protected project database. I relied on these field notes as a source of multiple perspectives on how the PLA youth participants, Daisy in particular, behaved and were evaluated outside of the PLA context.

7.2.2 Video logs

Within 48 hours of each PLA session, I digitized the footage collected from the session. This was a real-time process, meaning that the amount of time it took to digitize the footage was equal to the length of the footage. During and immediately after the digitizing process I produced logs of the footage, in which I wrote brief descriptions of the events that took place. I divided these descriptions into five minute blocks in order to ease future navigation of the video, should I need to return to the footage for more detailed analyses. In addition to writing basic descriptions of events, I also highlighted events that appeared relevant for understanding what and how learning was taking place in the PLA (e.g., explanatory activities, teaching interactions). In some cases I transcribed speech in which participants articulated their understanding of the material, and/or of the PLA as a whole. These logs became my primary source for navigating the massive archive of video and audio data collected, as they served as a searchable set of texts of the history of the activity.

7.2.3. Audio/video transcripts

Transcripts of audio and video were produced for three telementoring sessions that met the criteria of success (see Section 4 above).

7.3 Participant-produced media

The participants produced a variety of media over the course of the project. Below I catalogue those media that I focused on in my research.

7.3.1 SAM movies

All SAM movies produced by participants were saved and archived each time the participant worked on the movie. This produced a developmental record of each movie, which made it possible to observe how the participant(s) revised their movies over time until they created a final version.

7.3.2 CCS screen capture

Screen capture software as well as hand-held video of the monitor displaying the CCS were employed to record the use of the CCS in real time.

7.3.3 Miscellaneous PLA participant-produced media

Over the course of the project participants produced a variety of ephemeral media, such as: circuits using batteries, light bulbs, wires and switches, as well as drawings of circuits and light bulb architecture using personal dry erase boards. The majority of these products were documented via video.

7.3.4 Media produced by members of the research collaborative

Over the course of the PLA project, members of the research collaborative worked together to produce two manuscripts and two grant proposals related to the ongoing work of the project. I collected these documents primarily as records of the collaborative's members' public communications about their vision of the goals and methods of implementation of the PLA.

8. Up Next

The remainder of the dissertation is devoted to presenting my analyses (Chapters Three and Four) and to discussing the implications of these analyses for approaches to the design and implementation of after-school science education activities (Chapter Five). I begin the following chapter by examining events in the House Wiring Sequence.

CHAPTER 3: Analysis of a Successful Telementoring Session

1. Introduction

In this chapter I analyze the events leading up a long-sought-for success: Daisy builds a circuit suitable for lighting each of the rooms in her scale model home, such that each room can be lit independently given a single electricity source, “just like in a real house.” This was a moment that everyone present celebrated as a success. Daisy constructed the circuit appropriate for her house, and the researchers succeeded in demonstrating that she had learned to construct a parallel circuit. Below I trace the sequence of events within this session, descriptively building toward the moment in which collective action lead to these successes. Accordingly, I refer to this session throughout as the *parallel circuit session*. As noted, this session took place in the third and final sequence of the PLA, the *House Wiring Project* (Figure 3.1).

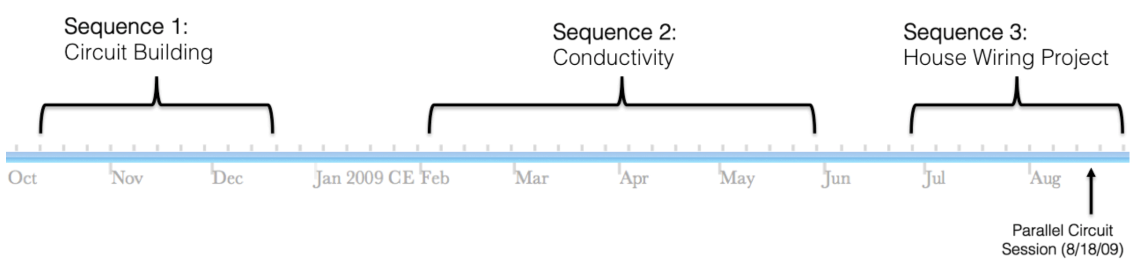


Figure 3.1: Timeline of the PLA. The actual schedule of completion for the topic sequences is shown together with the occurrence in this sequence of the focal session analyzed in this chapter (the figure is a reproduction of Figure 2.1, Chapter Two).

Following a brief introduction of what I consider the *mediational strategies* deployed by the participants in the parallel circuit session, I present the chapter in three main parts. First I begin with an overview of the general arc of the session itself leading up to the celebration of success. Then, using the participants' mediational strategies as *analytic categories*[5] I present my analysis of the changes over the course of the session that result in the celebration. Third, I conclude by arguing that the nature of the success cannot be entirely attributed to Daisy. The advantage of using analytic categories derived from the participants' own mediational strategies in the collective achievement of success becomes evident in this respect: they enable us to trace the origins of the many processes that enable collective action in the PLA activity system to *be* a success that is not the product of individual action only.

1.1 Three Kinds of Mediation

I identify three recurrent *meditational strategies* that participants use to balance their different understandings of what is transpiring as they jointly construct an appropriate circuit for lighting Daisy's model home. I refer to these strategies as backchanneling, translation, and tool-use:

1. *Backchanneling*: refers to acts of interpersonal coordination that make deliberate use of communicative behaviors outside of the awareness of select persons involved in an

5 I use these categories in combination with the well-established categories of *interactional stance* and *participation frameworks* (Goodwin, 2007a; Goodwin & Goodwin, 2004) used in multi-modal conversation analysis.

activity. This form of mediation is motivated in part by a desire to develop and/or maintain interpersonal harmony in the activity. In the idioculture of the PLA, maintaining good interpersonal relations was a crucial value. Daisy could leave whenever she wished, as she was there voluntarily, and so it was important for the instructors to keep on good terms with her. Equally, common sense dictated that Daisy and I remain on good terms with Tom, the person responsible for instruction.

2. *Translation*: refers to the work of coordinating across the two activity systems that formed the PLA: that of the physics instructors and of the Learning Lounge. It is a process of "revoicing" (O'Connor & Michaels, 1996) or "reconceptualizing" (Cazden, 1988) the ways in which participants come to know in one activity system in order to make them epistemically valid in another activity system.

3. *Tool-use*: the ways in which material tools in the PLA activity system were incorporated into the teaching-learning process.

1.2 Participation Frameworks and Interactional Stances

The three mediational strategies became "visible" in the actions that participants took to balance their contrasting understandings of their joint activity. To characterize these actions in a way that highlights the tensions and discoordinatons which these strategies mediated, I use the vocabulary of *participation frameworks* and *interactional stances* (Goodwin, 2007a). A participation framework describes the mutual attention that interlocutors continuously co-construct in interaction with one another. This attention involves the situated use of language and embodied actions — interactional stances — that interlocutors perform and through which they display their orientation to the participation framework.

2. The Arc of The Parallel Circuit Session

As noted above and in Chapter Two, the third major sequence in the PLA involved the wiring of a scale model home so that the individual rooms could be lit independent of one another. The *parallel circuit session* in this sequence is of particular importance because one of the goals of the PLA was to teach the construction of parallel circuits and related physics concepts. Notably, the primary pedagogical tool used during the entire house wiring sequence was the Circuit Construction Simulator software (CCS, Section 3.3.2, Chapter Two), which was explicitly designed for teaching electrical circuitry.

What was novel for Daisy about this telementoring session was that she was only allowed to use a single battery as the sole energy source for all four of the bulbs. Up to this point, we had focused on having Daisy build virtual or actual circuits composed of just one battery and one light bulb. Now, because she planned to have four rooms in her house, Daisy needed to use wires to connect *four* light bulbs and *four* switches to *one* battery to produce a circuit that contained four bulb-switch pairs that could be independently activated.

I divide the arc of this session into three phases. The boundaries of each phase are defined by explicit shifts in the teaching-learning objects at different points in the session:

1. Phase 1 - *What does a switch do?*
2. Phase 2 - *Building, diagnosing, and repairing a two-bulb, two-switch parallel circuit*.
3. Phase 3 - *Building, diagnosing, and repairing a four-bulb, four-switch parallel circuit*.

2.1 Phase 1 - What does a switch do?

The session began with Daisy using the Circuit Construction Simulator (CCS) to construct a two-bulb, two-switch parallel circuit. She got as far as incorporating the first light bulb and switch but soon discovered that activating the switch had no effect. The bulb was lit continuously.

Next, Daisy built a "do-over" one-bulb, one-switch circuit. This switch worked, but when Tom and I asked Daisy why it did, she had trouble explaining herself. Tom suggested taking a break from using the CCS, and instead using actual circuit building materials to construct a circuit that included a switch. This brief foray into actual circuit building led me to use a real switch as a prop for showing Daisy how a switch could produce a *gap* in the circuit, thus interrupting the flow of electricity. Daisy still didn't seem to understand. Tom then proposed that we revisit the CCS circuit. This time Daisy was able to explain how the switch functioned, describing it as a device that “creates a gap” prohibiting the energy from flowing. She also modified her “do-over” circuit in a way that demonstrated this understanding.

2.2 Phase 2 - Building, diagnosing, and repairing a two-bulb, two-switch parallel circuit

After getting straight how a switch functioned in a circuit, Daisy returned to constructing the two-bulb, two-switch parallel circuit. She built a two-bulb, two-switch circuit, but it wasn’t a parallel circuit. Instead, Daisy made an extraneous connection between one of the light bulbs and the sole battery in the circuit. As a result, the battery ended up “short circuited” being connected to itself. This burned out the battery, rendering the switches in the circuit non-functional.

Next, Tom and I guided Daisy through an inspection of the circuit to identify what was wrong. Daisy quickly recognized that the battery was connected to itself *and* she identified the wire that needed to be removed in order to remedy this situation. Tom acknowledged her point but continued to walk her through an inspection of the circuit before moving on to fixing it. Intent on having Daisy articulate her understanding of the problem *before* actually fixing it in the CCS, Tom persisted in asking Daisy more questions. Daisy soon became disengaged from the activity.

At one point in all of this, Vicente, a teenage friend of Daisy’s, unexpectedly joined the activity. Vicente’s presence occasioned another inspection of the faulty circuit. This time, however, Daisy got the opportunity to remove the extraneous connection, and discovered that she now had in front of her a functioning two-bulb, two-switch parallel circuit.

2.3 Phase 3 - Success! Building, diagnosing, and repairing a four-bulb, four-switch parallel circuit

Next, I asked Daisy to add a third bulb and switch to the circuit on the CCS. She used wires to connect the third bulb to the battery, forgot the switch, recognized her omission, and proceeded to start over, this time adding the bulb, switch and wires in a way that allowed her to light this bulb independently of the others. Success!

Tom and I erupted in cheers, and Daisy leaned back, pointed to herself and said, “I'm a genius.” She now had a three-bulb, three-switch parallel circuit. I excitedly told Daisy to add a fourth bulb and switch. In the process of adding these materials, Daisy incorrectly connected both the bulb and switch to the positive end of the battery. Critically, she immediately identified the problem both verbally and through gestures, and without assistance corrected it by connecting the bulb to the positive end of the battery and the switch to the negative end. When she activated the fourth switch the final bulb lit. Success again! The four-bulb, four-switch parallel circuit was complete.

3. Explaining the Road to Success: Mediational Strategies within Participation Frameworks and Interactional Stances

Interaction among participants in a PLA telementoring session, like all forms of instructional interaction, is structured by communication about what and how people know. Characterizing the dynamics of communication in the PLA is therefore important for understanding if and how it succeeded as a learning activity. In the remainder of the chapter I study the communication in the parallel circuit session, drawing on what I describe as *mediational strategies* together with two established constructs in conversation analysis: *interactional stance* and *participation framework* (Goodwin, 2007a; Goodwin & Goodwin, 2004). These concepts are relevant because they are used to characterize how people display what they know, and how their actions within culturally-constituted environments both constrain and enable processes of knowledge production. Mediational strategies refer to patterns of behavior deployed to resolve interpersonal and intellectual tensions rooted in different understandings of collective participation among Tom, Daisy, and me. I identify three mediational strategies, which I will use also as analytic categories: *backchanneling, translation,* and *tool-use.*

3.1 Participation Frameworks and Interactional Stances

For instructional interactions to succeed there needs to be a "common ground of engagement" (Matusov, 1996) between instructor and learner. That common ground requires that there be some degree of consensus about the nature of *participation*. The actions performed by interlocutors must demonstrate forms of involvement within evolving structures of talk (Goodwin & Goodwin, 2004, p. 222). These actions include the mutual attention that interlocutors engage in as both hearers and speakers, and the systematic modifications to their own and other's behaviors performed in order to manage and assess one another's actions. As defined by Goodwin (2007a), a *participation framework* is continuously co-constituted by interlocutors through their use of language and embodied actions - their *interactional stances* - to mutually align with one another and the environment in order to produce a shared focus of attention.

The co-construction of a participation framework involves power. This is particularly salient in instructional interactions where traditionally the learner is expected to adopt interactional stances that demonstrate acquiescence to the *collective participation framework* the instructor deems appropriate. However, the willingness and ability of a learner to contribute to and sustain a collective participation framework cannot be taken for granted. Anything from misinterpretations, failures of understanding, to pride can lead learners to contest the framework, undermining the means and ways that instructors propose to help learners learn.

In the remainder of the chapter, it is Daisy's contesting of Tom's definition of a collective participation framework that is the focus of my analyses. In these analyses I draw on the language of interactional stances in order to describe this dynamic of contestation. By way of introducing terms for different kinds of stances, I turn now to an example from Phase 1 of the parallel circuit session.

3.1.1 Types of Interactional Stance: An Illustration

Interactional stances display a person's *orientation* to the collective participation framework. According to Goodwin (2007a), these can be distinguished in terms of five interrelated stances: *instrumental*, *epistemic*, *cooperative*, *moral*, and *affective*. I draw on an example from Phase 1 of the parallel circuit session in order to illustrate each of these stances.

Recall that late in Phase 1 I used a physical switch to show Daisy how a switch created a gap in a circuit. Using the switch, I pointed out the two contact arms on the switch and the fact that when the switch lever was up, there was gap between the two arms that prevented electricity from flowing across. In order for Daisy to be able to take in this demonstration she had to physically position herself so that she could see all the elements of the demonstration. By positioning herself to take in my mini-lesson she was taking an *instrumental* stance. My performance of this lesson - the way in which I manipulated and described the switch to call Daisy's attention to relevant features - constituted an *epistemic* stance. What distinguishes the epistemic from the instrumental is the idea of relevance of features. In an instructional interaction, relevant epistemic features are those required for acquiring the knowledge being taught and assessed. My switch demonstration was meant to organize Daisy's attention and action in ways that would help her grasp the idea of a switch as a gap.

Critically, this moment in the parallel circuit session was one of high tension. As noted, Daisy had been struggling with the material up to this point. Tom and I were having trouble hiding our frustration. Daisy was clearly disengaged and confused. While she was instrumentally positioned to take in the lesson, she did not make eye contact with me throughout the demonstration, including during moments when I asked her direct questions. I interpreted this behavior as a refusal to take a *cooperative* stance toward the collective participation framework. Furthermore, the impression of non-cooperation was for me compounded by prior displays of annoyance and frustration that Daisy made in response to persistent questioning by Tom. Daisy's failure to cooperate created an environment for the visible emergence of *moral* and *affective* stances. In this case, from my perspective Daisy's non-cooperation was a moral stance, one that communicated that at this point in the session she would not behave in ways required to carry out the collaborative actions Tom and I were "asking" her to perform.

The perception of non-cooperation from Daisy also provoked an affective stance on my part. I showed my frustration with Daisy's evasiveness. As Tom continued to question Daisy about the switch, I turned away from the table where I had placed the switch for the demonstration. I began to work on a minor task that was not immediately relevant to what we were doing. My disengagement was both affective and instrumental. In making myself physically unavailable to Daisy, I both showed her my frustration and I made it difficult for her to solicit my help. Here I was adopting a non-cooperative stance.

To summarize, interactional stances are useful constructs for characterizing the variety of ways in which interlocutors orient to the collective participation framework, and thus help us understand if interlocutors are aligned or not in their orientations.

3.2 Mediational Strategies

In what follows, I present a series of examples in which I draw on the constructs of participation framework and interactional stances to highlight moments of interpersonal and intellectual tension in the parallel circuit session. I couple the focus on frameworks and stances with an analysis of the mediational strategies that resolved the tensions evident in the struggles to maintain a common participation framework.

I present four examples of how mediational strategies introduced above -- *backchanneling, translation,* and *tool-orientation* -- function to maintain the collective participation framework in the parallel circuit session. Examples 1 − 3 each illustrate one of the three mediational strategies. Example 4 illustrates the coordinated use of all three strategies at play simultaneously. My characterization of the strategies focuses on the way they mediate tensions arising from Tom's approach to instruction, Daisy responses to this approach, and my efforts to mediate between Daisy and Tom. I also keep clearly in mind the available material conditions for communication, emphasizing in particular the role of the video chat medium and the CCS in shaping our interactions.

For each of the four examples, I include a detailed transcript of the event, accompanied by video of these events from various angles. The videos can be accessed via the web or from the DVD submitted with the dissertation. I strongly suggest viewing the videos as a prelude to interpreting the textual reduction of the processes involved in each of the events. The written account, of necessity, condenses and makes linear aspects of the interactions that complexly overlap and intertwine with each other in theoretically and practically significant ways.

To supplement the information evident in the video clips and transcripts, I include figures schematically reproducing the CCS circuits as they appeared on the computer monitor that Daisy and I were using. These figures, of necessity, are static compilations of the state of the circuits at a moment in time. To see exactly how the circuits appeared as Daisy, Tom, and I saw them on the monitor see Figure 2.4 A, Chapter 2 (p. 41)

3.2.1 Mediating the Interpersonal Through Backchanneling

As noted, Phase 1 of the parallel circuit session began with Daisy attempting to build a two-bulb, two-switch parallel circuit. Daisy proposed to start by constructing a functioning one-bulb, one-switch circuit and proceed by adding to it another bulb and switch. She immediately ran into difficulties when she couldn't functionally incorporate the first switch into the circuit (Figure 3.2).

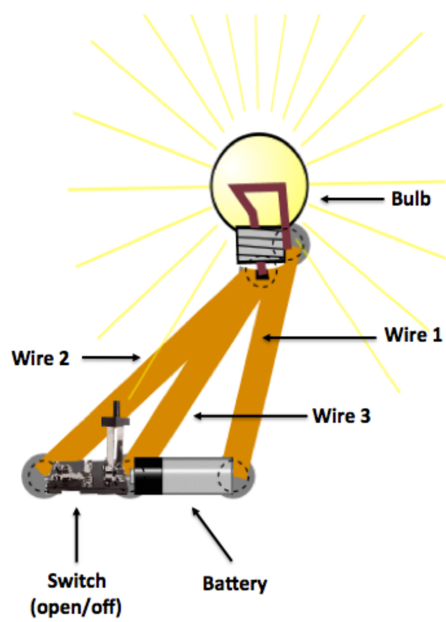


Figure 3.2: The first circuit built by Daisy in the parallel circuit session. Note that although the switch is in the "off" position, the light bulb remains on.

Tom guided Daisy to think about the role of the switch in the circuit:

Video 3.1: Example 1- Backchanneling (transcript) [6]

1 Tom: so what does the switch do? (1.5)

2 Daisy: it only um

3 T: I mean what do we

4 what does it do in general?

5 like

6 D: it's supposed to turn it on and off

7 turn the [ba]

8 T: [yeah]

9 D: the [light bulb]

10 T: [and how does it] do that? (1.0)

11 D: by stopping the energy going through the light bulb through the

12 battery through the filaments. *((furrowed brow))*

13 T: mkay

14 so why isn't it stopping (.) it right now?

15 D: because (0.5) the switch doesn't have control of the circuit

16 Robert: *((nods head in agreement))*

17 D: it just it's just sitting there.

---

[6] Videos accessible via the DVD submitted with the dissertation (path: chapter-3/3.1_Example 1) or on-line via the Proquest system (file names: chpt3-video3o1-ex1-f2f.mov; chpt3-video3o1-ex1-split.mov).

Video 3.1: Example 1- Backchanneling (cont.)

18	T:	so when you say in control what do you mean by 'in control'?
19	D:	*((collapses forward, head tilts))*
20	R:	*((turns head towards Daisy, smiling))*
21	D:	it's supposed to um (.) register the energy to turn it on and off
22		*((traces finger over circuit from left to right))* (1.5) (or)-
23	T:	right
24	R:	*((nods in agreement, thumbs up))*
25	D:	on and off
26	T:	sure
27	D:	yeah *((turns to Robert, furrowed brow))*
28	T:	but when you look at it right now
29		[so the light bulb is on right?]
30	R:	*((to Daisy, smiling))* [°(you can do it) (???)]
31	D:	*((smiling))* [@@@]

Reading back through the transcript we see that Tom is deliberately orienting participation through epistemic stances that are distinctly school-like. He employs a very classroom-based, canonical initiation-response-evaluation (IRE) mode of triadic instructional discourse (lines 1, 4, and 8 for example; Cazden, 1988; Mehan, 1979). Daisy initially appears to be aligned with this mode of participation. She offers responses that are correct (line 9) but the fact that Tom continues to ask her questions suggests that these responses are not sufficient. With each question that Tom asks, Daisy becomes increasingly frustrated and she refuses to take on a cooperative stance with respect to the collective participation framework that Tom is promoting. This refusal is apparent in the way that Daisy furrows her brow (line 12), collapses forward, and tilts her head (line 19). That these behaviors signal non-cooperation is reflected by the fact that I attempt to align myself affectively with Daisy through my sympathetic reactions to her behavior (line 20). Daisy tries to resolve her discomfort and confusion with Tom's continued questioning through *backchanneling* (lines 26-30).

Because it is an essential condition for backchanneling, I pause here to remind the reader of the blind spot induced by the video-mediated nature of the telementoring sessions. As noted in the previous chapter (Section 3.3.3, p.43), the medium of video chat placed certain limitations on what Tom could see of the local happenings in the Learning Lounge. What he sees of the space in which Daisy and I are working is limited to the area captured by a single webcam transmitting video from SDLC to Colorado (Figure 3.3). As a result, Tom cannot see my face and body nor Daisy's. He has to rely largely on the content and tone of our speech to monitor and communicate with us.

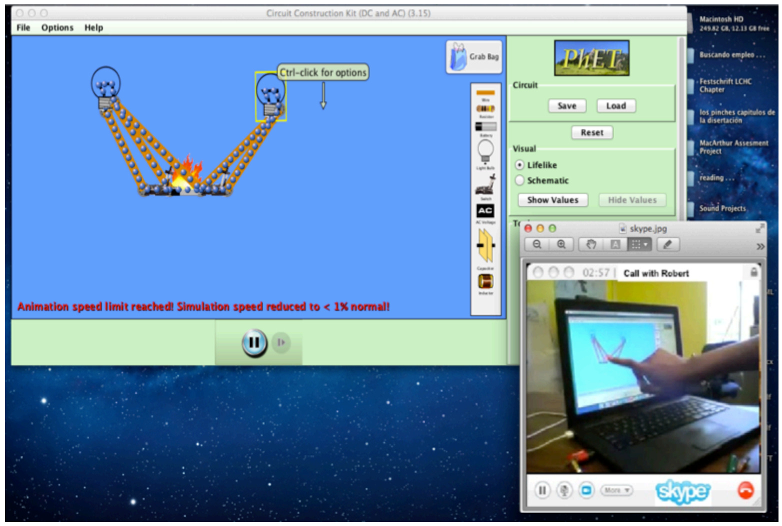


Figure 3.3: A screen shot of Tom's monitor during the parallel circuit session. Notice that Tom can only see the small area of the SDLC room captured by our webcam (lower, right window). This area is mainly populated by the laptop we are using to run the CCS. Notice also that Tom is simultaneously running the CCS on his computer in order to replicate the circuits Daisy and I are constructing locally.

Daisy and I exploit Tom's video-chat-induced "blindness" to backchannel. The whispered and overlapping exchanges in this segment of the example indicate that Daisy and I are exploiting the fact that Tom cannot see us and that the audio is limited to communicate with just one another. After having her response acknowledged by Tom, Daisy quickly turns to me with a furrowed brow (line 26). This move conveys confusion about Tom's line of questioning, and does so in a way that fosters camaraderie between us without running the risk of upsetting Tom. I react by smiling sympathetically and whispering encouragement – a response Tom does not see and presumably does not hear.

Tom's inability to see our displays of camaraderie is consequential for subsequent instruction because it contributes to a growing underlying tension related to the differing understandings of participation at play here. Daisy signals acceptance of Tom's mode of teaching by continuing to answer his questions (line 27). However, through her body language (line 26) Daisy signals resistance to Tom's persistent questioning. My sympathetic response to these non-verbal cues lends credibility to Daisy's dismissal of Tom's implicit suggestion of how participation should unfold. Under these unusual communicative circumstances, backchanneling allows Daisy to simultaneously contribute to, and undermine, the organization of Tom's instruction: She misleads Tom about her orientation toward the activity, while at the same time cultivating the camaraderie and co-membership with me that supports our interpersonal relationship. This relationship permits Daisy to continue interacting with Tom as if she were fully engaged with him while at the same time fostering the feeling and expectation that I am "on her side." The collective participation framework is maintained despite growing tension.

3.2.2 Mediating between Tom and Daisy Through Translation

Example 1 exposed a tension between Tom's notion of appropriate participation, and how Daisy thought she did, should, or could comply with his expectations. Through backchanneling Daisy and I had created space to relieve this tension by establishing that we shared the impression that Tom's questioning was excessive. At the same time, however, this put me in a position where I had to assess and act on Tom and Daisy's changing interpretations of what counted as cooperative and moral participation. For example, I saw the value in Tom's attempts to model scientific thinking for Daisy. At the same time, I could understand how Daisy, after giving an answer that everyone had acknowledged as correct, might legitimately see this continued questioning as badgering.

I sought through translation to mediate these conflicting stances. Such an example of translation unfolded shortly after the events in Example 1. Having established that the circuit that Daisy had built (Figure 3.2, Section 3.2.1 above) was not working properly, I proposed that she fix the circuit so that the switch actually turned the light bulb on and off. As noted earlier, rather than fix the circuit she had originally built, Daisy decided to build a new “do-over” circuit to the left of the original (Figure 3.4).

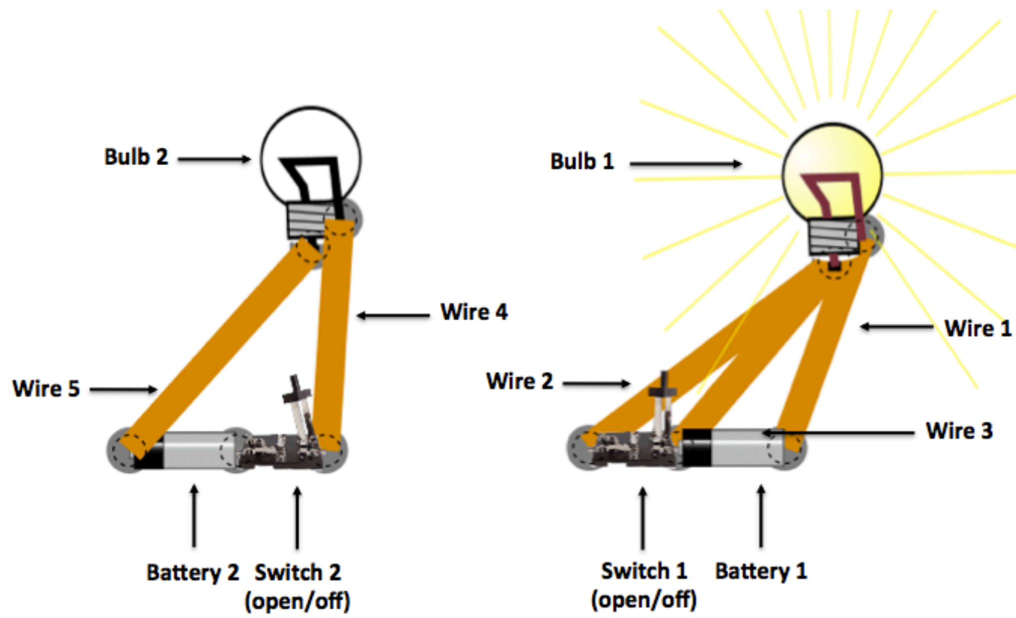


Figure 3.4: The “do-over” circuit (left) Daisy built as a fix to the first circuit she built (right). Note that both switches are in the open/off position, however, the bulb on the left in the new circuit is not lit while one on the right in the old circuit is.

The switch in this new circuit worked. Tom asked Daisy why:

Video 3.2: Example 2 - Translation (transcript) [7]

32	T:	when you (.) turn that switch up (.) why does the light bulb turn off? (3.0)
33	D:	*((turns off the switch (Switch1, Figure 3.4))*
34		because it has a (.) full control of the whole circuit *((traces counter-clockwise path over wires 4 & 5, Battery 2, Switch 2, Figure. 3.4))*
35		like (1.5)
36		everything is being controlled by that switch (1.0) *((rolls her eyes))*
37	T:	can you be a little more specific?
38	R:	*@@@ ((smiling))*
39	D:	*((rolls eyes))*
40		*((turns to Robert, smiling))* (6.0)
41		m::
42	R:	I gue-
43	T:	-sorry
44		that was a very open ended question
45	R:	no but I see

[7] Video accessible via the DVD submitted with the dissertation (path: chapter-3/3.2_Example 2) or on-line via the Proquest system (file names: chpt3-video3o2-ex2-f2f.mov; chpt3-video3o2-ex2-split.mov).

Video 3.2: Example 2 - Translation (cont.)

46 maybe that

47 maybe it’s it's the language that we're using.

48 and so you're saying it's in full control and I guess-

49 D: yeah

50 R: -that's what we're trying to figure out here what you mean by full control.

In this transcript we again have evidence of Tom adopting an epistemic stance that is aligned with forms of discourse typical of a classroom. He poses a known-answer-question (line 32), and asks Daisy to articulate her ideas verbally and precisely (lines 32, 37). Once again, Daisy hides from Tom the fact that she is taking a non-cooperative stance; and once again, she and I backchannel. Daisy rolls her eyes and smiles suggesting that she thinks she’s been precise enough (lines 38 – 41). I laugh and smile (lines 38, 40) communicating my recognition of the heavy-handed feeling of the questioning. Tom’s inability to see Daisy’s negative reactions to his questions combined with our backchanneling produce six seconds of silence.

I begin the *translation* process by breaking the silence (line 42). Unlike the prior example where I implicitly sanctioned Daisy’s resistance to Tom’s continued questioning, this time, through translation, I attempt to overcome the tension between sympathy with Daisy and showing that I agree with Tom’s implicit participation framework. I address Daisy with an ameliorating utterance (line 47) that simultaneously signals to Tom that

Daisy is uncomfortable. I also align myself with Tom, by rephrasing his question in more specific terms ("that's what *we're* trying to figure out here, what you mean by full control" lines 49 − 50). Translation in this case helps Tom understand what is happening locally, while at the same time, potentially, keeping Daisy engaged in the activity.

3.2.3 Daisy and Tom's Tool-use Mediation

The highlighted tensions over participation can be construed in terms of differences between Tom and Daisy's individual approaches to tool-use mediation with the CCS. In the two examples discussed thus far, Tom used the CCS to anchor his talk about circuits and engage Daisy in explicit verbal formulations. This use of the CCS articulated Tom's epistemic stance. It was a stance that conveyed an orientation to the participation framework, one that emphasized thought and communication about circuits in formal, discursive and generalizable ways.

Turning to Daisy, we see that she resisted Tom's proposed epistemic orientation. Through his continued questioning, Tom positioned Daisy so that she had to engage with the CCS on Tom's terms. This meant analyzing the virtual circuits through visual inspections and verbal dialogue. In contrast to this way of using the CCS, we see in the present example that Daisy could and did use the CCS to think and talk about circuits but in ways that were embodied, that involved the actual manipulation of elements in and on the CCS and that were not first verbally formulated. The contrast here reflects an epistemic conflict between Tom and Daisy. It is a contrast between Tom using the CCS to anchor his teaching, and Daisy acting on and with the CCS to think and communicate (that is, to engage in *thinking-by-acting*).

The present example is taken from Phase 2 of the parallel circuit session. Recall that in this phase Daisy mistakenly used three wires in an attempt to expand a one-bulb, one-switch circuit into a two-bulb, two-switch parallel circuit (Figure 3.5). The extraneous wire (Wire 2, Figure 3.5) prevented the electricity in the battery from flowing through the light bulb by diverting the electricity back to the battery (the path depicted by the white arrows).

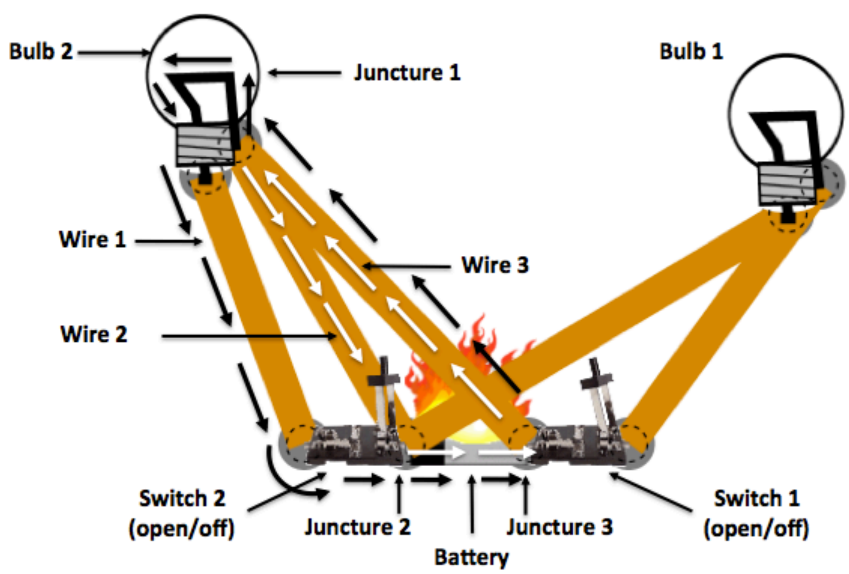


Figure 3.5: Daisy's attempt to construct a two-bulb, two-switch parallel circuit. The white arrows depict the path the electrons take in the circuit as it is configured. The thick, black arrows depict the path that the electrons should take in order for the switch to be functional.

As illustrated below, Tom used the faulty circuit as an opportunity to question Daisy extensively about the flow of energy in the circuit and why the light bulb (Bulb 2, Figure 3.5) was not lighting:

Video 3.3: Example 3 - Tool use (transcript) [8]

T: so (.) if the light bulb didn't turn on (2.5)
what does that tell us about the energy flowing through the light bulb?
D: it wasn't really flowing right
it wasn't flowing through (1.0) correctly.
T: I mean it wasn't flowing through (1.0) at all
D: yeah (2.0)
T: and you can tell that
how can you tell that? (2.0)
D: (???)
none of the energy was like-
((with mouse draws circle around triangular area formed by
Wires 1 and 3, the switch and battery, Figure 3.5))
none of the little blue balls were floating-
err floating - [flowing through
R: [can you] play it *((referring to the paused CCS))*
T: yeah
hit play again
D: *((hits play on the CCS))*
T: it's not a bad-
it's just
it
D: oh! *((points to Bulb 2, Figure 3.5))*
yeah *((traces down over wire #2 then traces right-ward over battery))*
((turns to Robert smiling))

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[8] Video accessible via the DVD submitted with the dissertation (path: chapter-3/3.3_Example 3) or on-line via the Proquest system (file names: chpt3-video3o3-ex3-f2f.mov; chpt3-video3o3-ex3-split.mov; chpt3-video3o3-ex3-closeup.mov).

Video 3.3: Example 3 - Tool use (cont.)

75 R: so it's not *((referring to the simulator))*
76 D: yeah
77 R: yeah *((nods head))*
78 so in here basically the (.)
79 neither of the light bulbs are part of the circuit (2.5)
80 so basically you have the battery connected to itself

The first thing to notice is how Daisy uses actions on and through the CCS to think and communicate. Tom asks Daisy how she can “tell” that the energy wasn’t moving through the light bulb (lines 57 - 58). In response, Daisy uses the cursor to call attention to the triangular area formed by Wires 1 and 3, the switch and battery (Figure 3.5) where “none of the energy was . . . flowing.” The fact that at this point in the interaction none of the electrons in the circuit were moving (i.e. energy is not flowing) is critical. Daisy’s activation of the animation function of the CCS (line 68) effectively “answers” the question posed by Tom: it shows that the only electrons “flowing” are those contained in the loop indicated by the white arrows in Figure 3.5.

Approximately three seconds after activating the animation function, we see a second example of Daisy’s thinking-by-acting on the CCS. Daisy exclaims in apparent recognition of the solution “Oh! Yeah” (lines 72 − 73) while simultaneously tracing the alternate path taken by the energy, moving her index finger over wire 2 from top to bottom and ending the gesture by moving rightward through the battery. As she completes this *environmentally-coupled gesture* (Goodwin, 2007b), Daisy turns to me for acknowledgment.

I respond to Daisy explicitly by nodding my head and saying “yeah” in agreement (line 77). Implicitly, the fact that I offer a definition of the problem with the circuit (lines 79 −80) aligns me epistemically with Daisy. It signals to her not only that her gesture was salient to me, but that is was convincing evidence that she understood what Tom was trying to get her to articulate: energy does not flow through the light bulb but instead flows down wire 2 and back into the battery. At the same time, by publicly defining the problem with the circuit I have undercut Tom’s epistemic stance: Daisy is not required to verbally explain the problem.

3.3. Shifting Epistemic Orientation: Daisy builds a parallel circuit

In this section I examine the three mediational strategies and the tensions that they mediated by focusing on a final example in which all three strategies are clearly intermeshed. The example I review is of a crucial moment in which there is a consequential epistemic and affective shift in the collective participation framework. This shift, I argue, helped create the conditions that allowed Daisy to finally construct a two bulb-two-switch parallel circuit. Building this circuit was precisely what Daisy needed to do in order to accomplish her goal of lighting the four rooms in her scale model home (i.e. making a four-bulb, four-switch parallel circuit).

Following the events in Example 3, Tom initiated yet another round of questions and suggestions designed to elicit the sort of verbal explanation he was seeking from

Daisy. Early in this interaction, Daisy recognized the problematic wire that needed to be removed from the circuit in order to fix the problem and so build a two-bulb, two-switch parallel circuit (wire 2, Figure 3.6). She identified this wire for Tom. Critically, although Tom acknowledged Daisy's correct answer, he continued questioning her *with the problematic wire still in place.* At this point in the session he was intent on having Daisy learn scientific concepts (e.g. *resistance)*, not on allowing Daisy to go ahead and *build* the parallel circuit for her scale model home.

With the problematic wire still in place, Daisy was so perplexed by Tom's continued questioning that at one point she flatly declared that she didn't understand one of Tom's questions. Tom, needing the problematic wire in place in order to make contrasts relevant to promoting an understanding of resistance interpreted this to mean that Daisy did not understand the significance of the superfluous wire. Daisy, on the other hand, was expressing her confusion about Tom's relentless questioning given that, from her perspective, the problem had been solved.

Daisy became so alienated that she simply stopped trying. Daisy's disengagement finally became obvious to Tom. Sensing a problem, Tom asked me if I had anything to add.

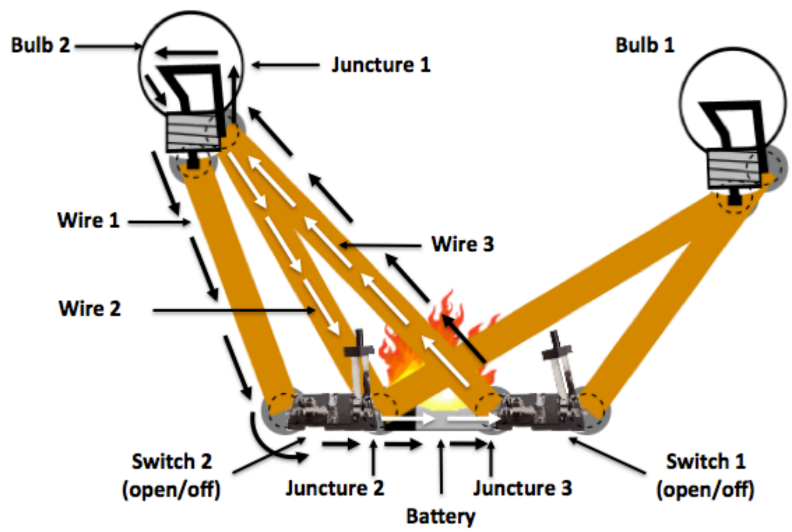

Figure 3.6: Daisy's attempt to construct a two-bulb, two-switch parallel circuit. The white arrows depict the path the electrons take in he circuit as it is configured. The thick, black arrows depict the path that the electrons should take in order for the switch to be functional. (This figure is a reproduction of Figure 3.5. I replicate it here to allow the reader to more easily study the transcript and figure side-by-side.)

I had a vague understanding about resistance, the concept that Tom had insisted on trying to teach just a few moments before, so instead I took the opportunity to articulate how I understood the problem with the circuit. I saw things in terms of mechanics. Using Figure 3.6 as a guide, Wire #3 connects the negative end of the battery to the side of the light bulb cap (Juncture 1) where it "delivers" the electrons from the battery; however, the electrons can't enter the bulb because Wire #2 which is also connected to the side of the light bulb cap (Juncture 1) effectively diverts the electrons before they can enter the bulb and sends them back to the battery. As illustrated in the following transcript I explained this to everyone in the room, including Vicente who, as noted, had joined the activity at this point

Video 3.4: Example 4 - Shifting epistemic orientation (transcript) [9]

81	R:	it’s di[verting]
82	T:	[it's not block]ing but
83	R:	it's diverting *((turn to Daisy; fist to other hand gesture))*
84	T:	it's just giving it a
85		yeah it's diverting
86		it's giving it an easier way out.
87	R:	right
88		so if you wanted it to go through the:: (2.0)
89		uh (1.0)
90		through the light bulb what
91		what would you do?
92	V:	°take off the wire
93	T:	good question
94	R:	Vicente just said 'take off'
95	D:	[*((turns to Vicente, palms up, smiling, look of playful disappointment))]*
96	R:	[which wire?(1.0)]
97	V:	the one that's (0.5)
98		using to divert?

[9] Video accessible via the DVD submitted with the dissertation (path: chapter-3/3.4_Example 4) or on-line via the Proquest system (file names: chpt3-video3o4-ex4-f2f.mov; chpt3-video3o4-ex4-split.mov; chpt3-video3o4-ex4-closeup.mov).

Video 3.4: Example 4 - Shifting epistemic orientation (cont.)

99 R: which

100 point to it.

101 V: the one in the middle *((smiling))*

102 R: the one in the middle *((smiling))*

103 D: *((points to Wire 2, Figure. 3.6))*

104 R: ok *((smiling))* (2.0)

105 *((turns and faces Daisy, pointing to her with open hand))*

106 [°give it a (???)] (nods)

107 T: [and (what/why) would be

108 D: [(???) *((smiles))*]

109 T: why would you wanna do that and what would that do?

110 D: *((moves cursor to Wire 2, Figure. 3.6))*

111 (4.0)

112 R: *((turns to Vicente and Daisy))*

113 a:: either Vicente or Daisy it doesn't matter

114 you guys

115 you wanna explain? (1.5)

116 [so why]

117 D: [*((removes Wire 2, Figure. 3.6))]*

118 R: ok

This encounter signals a consequential shift in the epistemic orientation of the collective participation framework, away from the more formal mode that Tom was promoting, to the more informal mode typical of the Learning Lounge. The shift unfolds through translation. By framing the problem with the circuit as a mechanical one (a wire "diverting" electrons), I reorient participation away from a focus on using more formal scientific concepts toward practical solutions based on reconfiguring the circuit (lines 88 − 91). Although not entirely on board (line 86), Tom acquiesces to the change in framework by adopting my vocabulary (line 85).

There is a history to the framing of the problem with the circuit as a mechanical one. This framing is based on an understanding of electrical flow in a circuit by analogy with fluid flowing in pipes. As described in Example 3, the animation feature of the CCS depicts the flow of electricity similarly. It shows the electrons (the "little blue balls") moving *through* the wires, batteries and bulbs of the circuit. It is through this fluid metaphor that Daisy, Tom, and I had up to this point been talking about electrical flow in circuits, both in telementoring sessions, and in local (off-line) sessions. At the same time, the shift to "do something" to the circuit (line 91) as a problem-solving measure can be linked in part to the fact that the CCS, as a simulator, affords reasoning through trial and error manipulation of the circuit elements (Perkins, Adams, Dubson, Finkelstein, Reid et al., 2006). This kind of manipulation, as seen in Example 3, was characteristic of Daisy's tool-use.

There is a second sense in which translation in this example brings about a shift in epistemic orientation. Both by inviting Daisy *and* Vicente to address my questions (lines

91, 113), and by accepting Daisy and Vicente's responses, be they verbal (lines 92, 100) or embodied (lines 103 − 106) , as legitimate contributions to the conversation (lines 94, 96, 99-100, 102, 118), I am not adopting a cooperative stance toward the participation framework formed by Tom's insistent questioning of Daisy. The latter is a mode that positions Daisy as an individual learner. By treating Vicente and Daisy as equal participants I make visible a moral stance that has its basis in the Learning Lounge norms and pedagogy: when arranging learning activities, privilege multi-media communication among multiple participants.

Furthermore, Vicente's presence makes evident that with the shift in epistemic orientation there was a parallel shift toward a more positive affective orientation that reengages Daisy. When Vicente correctly suggests removing a wire (line 95), Daisy smiles and playfully feigns disappointment. Vicente and Daisy proceed to jointly identify the culprit wire (lines 101 and 103) and this too produces smiles all around. Then in another clear sign that the epistemic orientation has shifted, Daisy (at last) *uses* the CCS and begins to remove the culprit wire (line 10). This move appears to be prompted by backchanneling between Daisy and me. After she points to the culprit wire (line 103), I turn to her, and while Tom is speaking I point to Daisy, whispering and smiling. Daisy smiles and fixes the circuit.

As noted in Section 2.2, Daisy's removal of the culprit wire is the event that allows her to go on to build the four-bulb, four-switch parallel circuit. With the wire gone, she now recognizes that she has a two-bulb, two-switch parallel circuit. The new epistemic orientation is clearly in place as I encourage her to "do" - that is to add bulbs, switches and wires to the circuit so she can accomplish the goal of building the four-bulb, four-switch circuit (Phase 3). At the same time, Tom hangs back, no longer trying to intervene as often as he had before.

4. Tom's Logocentric vs. Daisy's Pragmatic Orientations

Each of the four examples reviewed above highlight the fact that interlocutors are situated within multiple, distributed and interrelated participation frameworks (Engeström, Engeström, & Karkkainen, 1995). This was evidenced by Daisy and Tom's different epistemic stances: these conveyed different understandings of how the collective participation framework should be organized. On the one hand, Tom's stances conveyed what I have referred to as a *logocentric* epistemic orientation. He used the CCS as a scaffold to model formal, scientific ways of thinking and talking about circuits. In contrast, Daisy tended to adopt epistemic stances that were localized and practical, combining embodied ways of thinking and talking about the circuits with strategic moves to recruit me as a surrogate. These stances conveyed a *pragmatic* epistemic orientation to the participation framework.

Tom's logocentric orientation was organized to educate Daisy's attention to "see" circuits like a physicist (Ingold, 2000). Accordingly, when Tom instructed Daisy he emphasized the use of descriptive and analytic talk about the circuits *before* actually doing anything to build or rearrange them. For example, in his exchanges with Daisy he focused on reducing tasks into series of concrete and manageable operations that modeled his analytic approach (e.g. Example 3, lines 79 − 86).

Tom's emphasis on the verbal and logocentric betrayed an expectation not only that Daisy should develop fluency with scientific concepts (e.g. resistance), but that she also have an inquisitive and analytic disposition. This was evident in an exasperated exchange that unfolded early in the session. In the transition between Phase 1 and 2, Daisy had trouble remembering how to build a circuit she had previously built. I suggested she ask Tom for clues since he had originally helped her with this circuit. Daisy checked with Tom. He responded with noticeable irritation:

> "This is the thing, it's not about remembering. I'm glad you forgot how to make [the circuit] cuz if you could just remember how to do it then you could just sit down and make it again. But if we had to figure out how to make four or seven [bulb circuit] or what have you . . . that's what you gotta be able to do. You gotta figure out how to make more and more . . . *Cuz the idea here is not to kinda guess and check but to actually know why the thing works.*"

In bringing up "guess and check" Tom was referring to Daisy's tendency to use trial and error as her primary strategy for building circuits. Daisy had in fact taken this approach when she built the faulty circuit that became the focal problems in Phase 1 (Figure 3.2, Section 3.2.1 above). She had also done this when she first tried to build the two-bulb, two-switch circuit (Figure 3.5., Section 3.2.2 above).

Daisy's penchant for using the CCS in the exploratory way that Tom objected to is characteristic of her pragmatic orientation to the participation framework. For Daisy, thinking and talking about circuits was best accomplished by actually manipulating the CCS circuits (e.g. Example 2, lines 33-34), as well as by using the CCS as an anchor for environmentally coupled gestures (e.g. Example 4, line 73). Daisy's tendency to rely on the CCS to think about circuits was antithetical to the kind of formal, verbal orientation that Tom was modeling for Daisy. As demonstrated in Example 4, this tension between logocentric and pragmatic orientations was disruptive to the flow of activity. Tom's insistence on keeping the faulty circuit up on the monitor in order to elaborate on the concept of resistance disoriented and alienated Daisy who didn't understand why she couldn't simply fix the circuit.

There were also instrumental-practical reasons for Tom and Daisy's epistemic orientations. Daisy was in fact using the CCS in the kind of exploratory fashion that the developers of the CCS had designed into this software (Perkins, Adams, Dubson, Finkelstein, Reid et al., 2006).[10] At the same time, the fact that Daisy and I had the CCS in front of us made it easier for us to act with and through it to explain ourselves and coordinate with one another.

Turning to Tom, his emphasis on verbal declarative knowledge may have also been linked to the fact that the telemediated organization of the PLA made speech the most practical way to communicate. The use of a single webcam to transmit the video feed from SDLC to Colorado meant that for the majority of the parallel circuit session Tom's view of the tech room was limited to an image of the SDLC computer screen displaying the CCS interface. Consequently, speech was Tom's primary means for shaping action at a distance in the tech room and for monitoring and communicating with

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10. "We design the sims [name for the class of simulations to which the CCS belonged] to present an appealing environment that literally invites the student to interact and explore in an open-style play area," (p.18).

Daisy and me. This fact, however, only foregrounds the ease with which technological "solutions" to learning can appear self-evident. In this case, video chat emphasizes a model of learning – concept-driven-behavior –that conflicts with the pragmatic orientation that Daisy was accustomed to.

In summary, Daisy and Tom's uses of the CCS throw into relief the conflicting logocentric and pragmatic epistemic orientations to the participation framework. The distinction between these two orientations can be specified with respect to Tom and Daisy's differing understandings of the ends to which the CCS was a means (Wertsch, 1998). For Daisy, using the CCS to *build* the four-bulb, four-switch parallel circuit was a core goal. However, Tom's continued questioning of Daisy throughout Phase 2, while leaving the incorrect CCS display in place, implicitly signaled that her goal was subordinate to his goal of using the CCS to teach her the *principles* of circuit building. What we witness in the parallel circuit session is a progression in which Tom's logocentric orientation is increasingly contested by Daisy to the point where there is a consequential shift toward a pragmatic epistemic orientation in the participation framework of the parallel circuit session.

5. A Critical Summary

At the outset of this chapter, I motivated the choice of the parallel circuit session to ground my analysis of instruction and learning in the PLA by highlighting the fact that our collective efforts produced a long-sought for success – a moment when all of the participants genuinely celebrated “Daisy’s accomplishment.” However, as the reader should be aware, and as anyone familiar with the ideas of Distributed Cognition and CHAT might expect, there are ample reasons to question the extent to which the success in question should be attributed to Daisy as an individual or to the group as a distributed problem solving system. Moreover, as Example 4 shows in particular detail, this success came at the expense of Tom abandoning his own pedagogical goals. A four-bulb, four-switch parallel circuit was created, but without any display of the kind of verbal articulation that was the key criterion Tom used to assess physics understanding.

Despite this ambiguity, the analyses of “Daisy’s successful problem solving” served me well as a means of identifying the logocentric and pragmatic epistemic orientations. The presence of these orientations confirmed questions I raised at the beginning of this thesis regarding conditions that could influence how university and community institutions interact in UC-Link type collaborations.

First, while sharing the goal of educating students, universities and community organizations can differ with respect to the idiocultures that define their value and knowledge systems (Konkola, Tuomi-Gröhn, Lambert, & Ludvigsen, 2007). Recall that at the beginning of this thesis we distinguished between formal and informal modes of teaching-learning in terms of differences in knowledge traditions (rational/scientific vs. practical/situational) and the degree of agency a learner exerts in the learning situation (from dominant teacher control to dominant learner control; Livingstone, 2006). Tom’s logocentric and Daisy’s pragmatic orientations are manifestations of contrasting systems of knowledge, or *epistemes,* and these epistemes reflect the overall logics of the two activity systems that make up the PLA: the formal logic of the Physics Education Group in Colorado and the informal logic of the Learning Lounge.

Second, when examined through a CHAT lens, the logocentric-pragmatic tension reminds us of the fact that the PLA was the object of activity between the Physics Education Group and the Learning Lounge activity systems. The PLA was more than just a shared object, it was an emerging activity system with its own tools, community, rules, and division of labor (Figure 3.7). The logocentric-pragmatic tension was visible in all of the relationships mediated by each of these constituents of activity (Figure 3.8). The node of "community" (in coordinated communication) is at the heart of this argument, as it is here that we locate the overlap of idiocultures in which different, potentially conflicting, epistemes, are held in productive tension and partial balance.

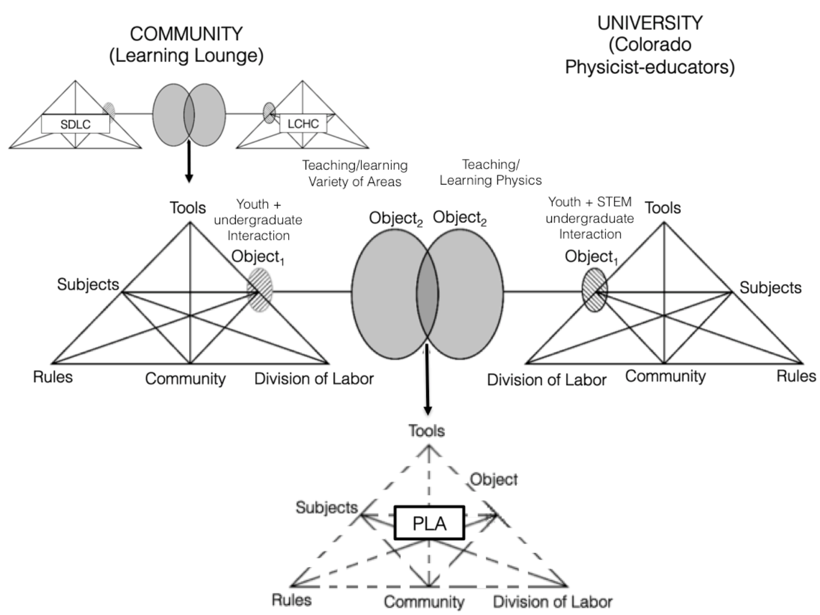

Figure 3.7: The PLA as an activity system emergent in the interaction of the Learning Lounge and Colorado activity systems.

The node of tools took up the bulk of the analyses in this chapter. Already discussed was the epistemic contrast in tool-use mediation between Tom and Daisy, specifically with respect to their use of the CCS. However, this contrast was evident not only in *how* the tools were used, but in the choice of tools as well. Compared to using actual switches, and to working with the actual scale model home, the CCS was very much a logocentric tool. The premise behind the proposal that Tom and I made to use the CCS was that Daisy should figure out the circuit first and then apply what she learned to using actual circuit building materials to produce the circuit.

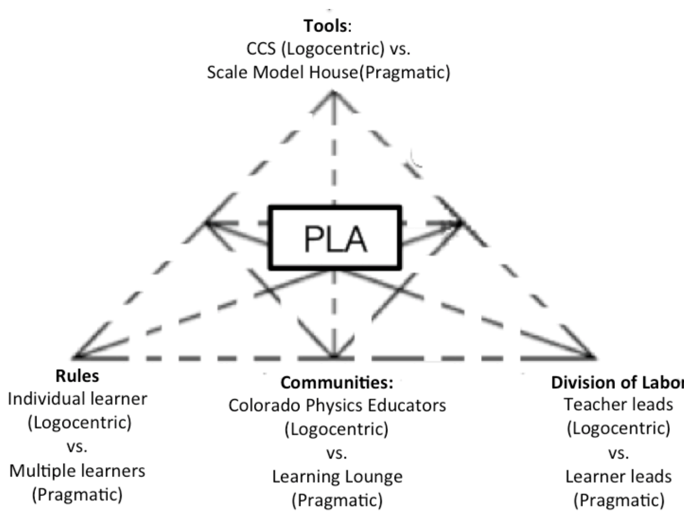

Figure 3.8: Examples of the logocentric-pragmatic tension manifested in the mediational relationships that constituted the PLA activity system.

There was overlap in how the logocentric-pragmatic tension was manifest in the rules and division of labor. At its core, the problem was about who was responsible for leading learning, and by extension, who could define what did or did not count as learning. The contradiction of brining in a physics expert to lead instruction in an informal learning setting (division of labor) created tension. Vicente's unanticipated participation heightened this tension, as it added to the unraveling of Tom's lesson which was already undermined by Daisy's growing disengagement. Vicente's involvement threw into relief the contrast between Tom's individually centered instruction and local norms (rules) that encourage participation in activities by any one at any time.

The balancing of these tensions in all of these nodes required the use of meditational strategies to "revoice" and coordinate the logics of the two epistemic orientations (translation) maintain interpersonal harmony within and between either side of the epistemic "divide"and articulate the instrumental logics (tool-use) at play within each epistemic stance.

Having identified these strategies, and their deployment in partially resolving (or resolving "enough") conflicts between starkly contrasting epistemic orientations inherent in the two very different activity systems that together constituted the PLA, the question naturally arises: Assuming that the differing epistemic orientations were characteristic of the two participating institutions from the beginning of the project, how did the mediational strategies evident in the current session arise? If we go back to earlier sessions and now view them through the analytic lens developed here, can we trace the developmental history that led up to this putatively successful moment and understand the transformations that brought it about? This is the topic of the next chapter.

CHAPTER 4: Development and Deployment of Mediational Strategies: A Cultural History of Daisy's Success

1. Introduction

Our analysis of the parallel circuit session in Chapter Three revealed two major findings. First, that the success of the session involved resolving interactional tensions induced by a fundamental tension in participants' pragmatic or logocentric orientations to the PLA. Second, we established the usefulness of three discernible mediational strategies for identifying and resolving these tensions — tool-use mediation, acts of translation, and backchanneling. These strategies enabled participants' to orchestrate attempts at resolving the fundamental logocentric-pragmatic contradiction to the point where they could celebrate their accomplishments.

In this chapter, I describe the transformation of the PLA from an activity the organization of which was largely defined by the logocentric episteme to one more in line with the pragmatic episteme of the Learning Lounge. I apply the logic followed in Chapter Three by highlighting and tracing the origins of a moment of qualitative change that was consequential for the organization of the PLA as a whole. The selected moment unfolded in a planning session two thirds of the way into the project. This session was instrumental in bringing about the circumstances of "success" under which Daisy built the parallel circuit described in Chapter 3. The events taking place in this session marked a sudden shift in our subsequent implementation of the PLA curriculum (see Figure 4.1, "Original Curriculum Restructured"). Note that this shift is reflected by a change in the way we referred to each of the curricular topic sequences. The first two sequences are named using distinctly logocentric terms (circuit building, conductivity), while the final sequence suggests a change to the pragmatic (house wiring project).

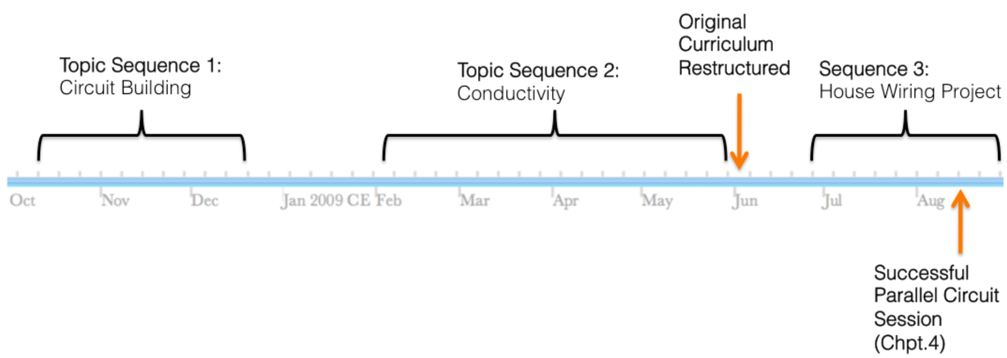

Figure 4.1: Timeline situating the moment when the PLA curriculum was re-structured to incorporate the House Wiring Project.

2. Three Disruption Clusters

As a means of identifying likely sites for observing how and why mediational strategies were deployed, I have selected a series of earlier events in which the group encountered conflicts that disrupted or threatened to disrupt to the flow of activity. These disruptions took place in all manner of PLA sessions - telementoring, local, and planning.

My analyses are organized chronologically around three series of disruptions - which I term *disruption clusters* (Figure 4.2). Each cluster emerged as we implemented the first two topic sequences of the electronic circuits curriculum. In each sequence Daisy used the focal tool, stop-motion animation movie software (SAM), in ways that we had not anticipated. Further, Daisy's novel uses of SAM shifted our focus away from the "logocentric versus pragmatic" contradiction that was identified as being central in the analysis presented in Chapter 3. In effect, Daisy used the tool intended to promote logocentric (scientific) understanding of the assignment in a pragmatic way.

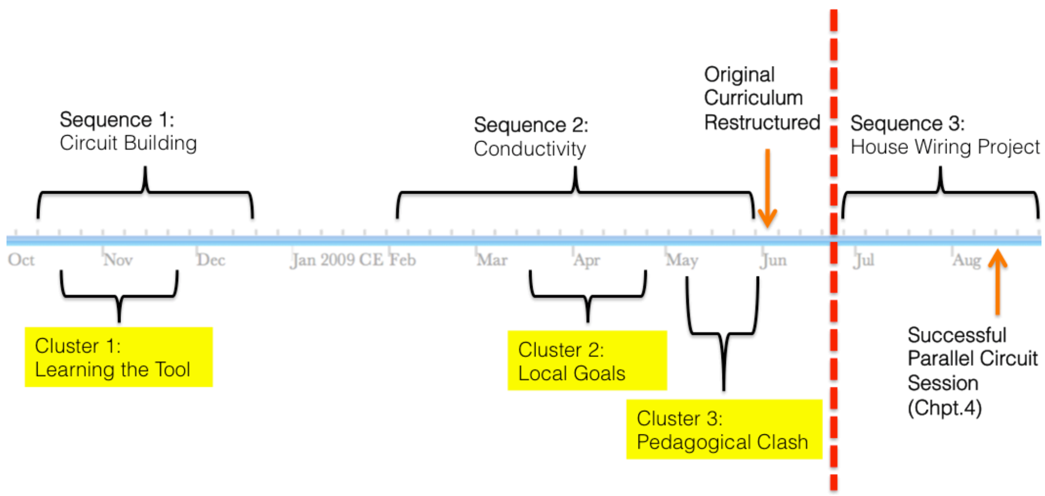

Figure 4.2: Timeline situating the three disturbance clusters as they appeared over the course of the PLA. The dotted vertical line represents the break in the trajectory of the PLA when we replaced the original curriculum with the house wiring activity.

Another characteristic of these disruption clusters is that they required marked changes to the organization of the PLA in order to restore the expected flow of activity. Under these circumstances, the various mediational strategies we used to resolve the ensuing crises are thrown into sharp relief.

Examined as a collection of interconnected events, these re-mediations trace changes in my own and Mary's satisfaction with the progress of the research. These events moved from a collective enthusiasm and no perceived threat to the stability of the project among the participants, to a period in which we focused on problems concerning the use of SAM - the focal tool (Cluster 1 - Learning the Tool), to a period where there was consensus that Daisy and I should handle some of this problem solving on our own (Cluster 2 - Local Goals,), and finally to a moment of conflict between Mary and me that rose to the level of a crisis (Cluster 3 - Pedagogical Clash). The actions that constituted this crisis, which I label here the *Pedagogical Clash*, were a clear expression of the conflict between the logocentric and the pragmatic epistemes. The crisis proved to be the catalyst for the major restructuring of the PLA from a logocentric activity to one grounded in the practically oriented house wiring project. The temporal location of restructuring is depicted by the dotted line in Figure 4.2.

This chapter can be read as the story of how translation, backchanneling, and tool use were deployed to resolve, or forestall, the problems that emerged as my colleagues and I struggled to implement the originally imagined PLA (Chapter Two, Section 3). We sought to implement a successful hybrid activity system in which the contradictory demands of the logocentric and pragmatic epistemes could work themselves out. The vertical red line in Figure 4.2 marks the tipping point when the pragmatic idioculture of the Learning Lounge overpowered the logocentric organization being imposed by the physicists, resulting in a consequential change in Daisy's tool-use within the PLA. It is this background of friendly yet tense negotiations "for the sake of the project" that sets the context for the celebration of success described in Chapter Three.

In this chapter we also examine the ways in which translation, backchanneling, and tool-use mediation were deployed over longer time scales (i.e. beyond a single session) and in multiple and varied sessions (i.e. telementoring sessions as well as planning and local sessions). By expanding our analyses to include planning and local sessions, we gain insight into the role that changing social configurations played in the deployment of mediational strategies. At the same time, viewing the PLA at a longer time scale reveals the different ways in which the mediational strategies were deployed in the various kinds of PLA sessions. Moreover, often the strategies were not applied in isolation from each other, but in different configurations, depending upon local, contingent and unexpected perturbations in the circumstances.

Finally, this chapter also highlights my role as what Kozulin (1998) has referred to as a *human mediator* (all humans, of course, as members of complex social groups, are mediators). My participation in the local video production sessions was especially revealing, as I had to improvise a great deal to be sure that all went well enough for there to be a "next time." At times my own lack of knowledge of physics, and my own involvement in an idioculture where "getting it done" trumped "learning to explain it," lead to a constant juggling of mediational strategies; rarely was a single strategy present in the teaching-learning process.

I remark on these matters as I present an account at the level of "disturbance clusters," but I postpone a more detailed discussion until the final chapter, at which point the reader will have a clearer view of how these processes played out over a period of months, as well as how they enrich our understanding of the celebration of Daisy's success, the object of our inquiry.

3. Cluster 1 – Learning the Tool

The first disturbance cluster emerged immediately following the first telementoring session in which Daisy was assigned to make a video explaining the six circuits she had been asked to evaluate as a part of that lesson (Figure 4.3). She focused on the circuit in Figure 4.3.

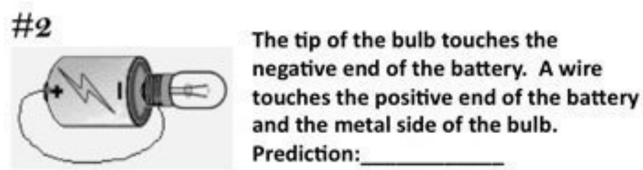

Figure 4.3: One of six battery/bulb circuits Daisy was asked to evaluate and discuss in the instructional phase of Topic Sequence 1. For all six configurations see Appendix B.

For that particular circuit, Daisy surprised us by making a video composed almost entirely of text and devoid of animation. Throughout the local video-production session I intervened in Daisy's SAM production intermittently with specific suggestions for how to incorporate animation into the storyboard Daisy had drafted for her video. Daisy, however, resisted, arguing that it would be "easier" to use words, that she needed words in order to "explain" the drawings that she included in her video, and that not using words would "mess" her "up."[11] Stills from her video are shown in Figure 4.4. The animation potential of SAM had been turned into a power point presentation, a format that Daisy knew well, both as an experienced student and through her involvement in earlier digital story-telling projects in the Learning Lounge.

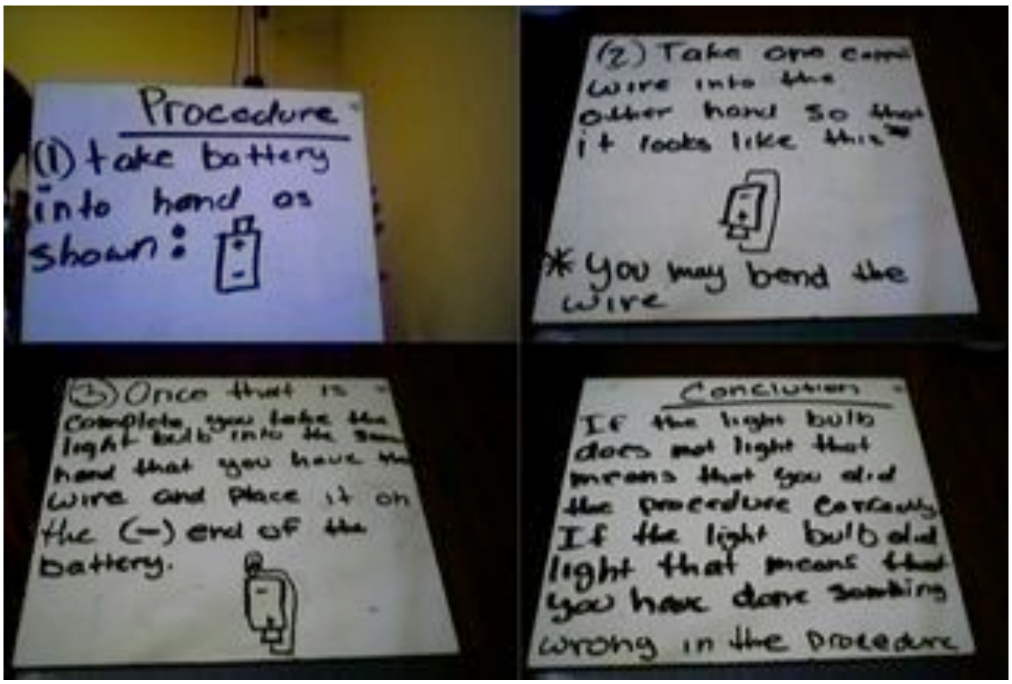

Figure 4.4: Select stills from Daisy's first SAM video. The video depicts Daisy's explanation of the circuit shown in Figure 4.3. Note the predominance of text and the lack of animations. Note also that in the final frame Daisy incorrectly claims that the given battery/bulb circuit should not light if properly constructed.

This disturbance cluster, labeled "Learning the Tool", involved two internal tensions (Figure 4.5). The first tension centered around our efforts to encourage Daisy to implement animation as a tool in scientific thinking. I refer to this as the *Text-Animation*

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[11] Quoted text in my descriptions of the three disturbances is drawn from transcripts of video documentation of the PLA sessions and/or field notes and video logs of these PLA sessions.

Tension. I refer to the second tension as the *Description-Explanation Tension.* When Daisy finally succeeded in making animations of circuits, she did so in a manner that was purely descriptive. She evaded the explanatory process lying at the heart of the logocentric episteme, embodied in both the tool and instructional procedures emanating from Colorado. The adjustments Mary and I made in order to improve the PLA succeeded in resolving the text-animation tension; however, the description-explanation tension remained unresolved. I consider each tension in turn.

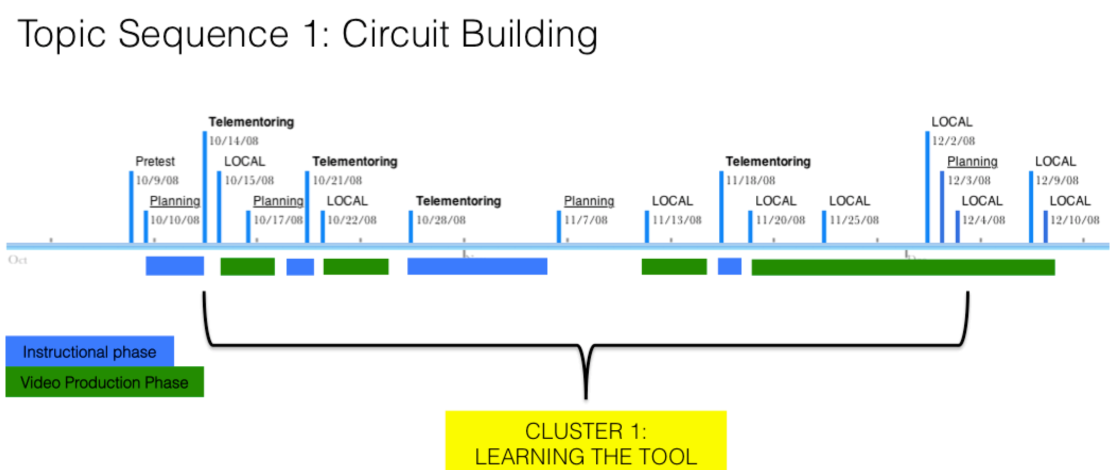

Figure 4.5: Timeline of PLA sessions in which the first Sequence of the curriculum (Circuit Building) was implemented. The bracket indicates the subset of sessions that constituted the Learning-the-Tool Disturbance Cluster.

3.1. Encountering and Resolving the *Text-Animation* Tension

A central object of the PLA research collaborative was to study the potential of *animation* as a tool for thinking and communicating about circuits. While at this stage Daisy's understanding of the basics of circuit construction was clearly minimal (e.g.,

Figure 4.5, final frame), Mary and I were more focused on resolving the “problem” of Daisy using text instead of animation in her filmmaking. Following the local session in which Daisy produced her video, Mary and I convened a planning session (10/17/08) in which we agreed that during the upcoming telementoring session (10/21/08) we should focus on encouraging Daisy to incorporate animations in her videos.

Our initial efforts were not successful. In the telementoring session (10/21/08), Mary encouraged Daisy to “be creative” with her videos by adding sound effects and colors; however, she did not make any specific suggestions about how to implement the animations. In Daisy’s next SAM video (local session, 10/22/08), she simply added a voice-over track that consisted primarily of her reading aloud the text displayed in each frame. Daisy was entirely in charge of production because I happened to be absent on that day. Video records of the session show that the undergraduate who was there to supervise, did nothing to encourage Daisy to animate. She complied with the “letter of the law” of the instructions, but she entirely bypassed its underlying intent.

In our next planning session (11/7/08), Mary expressed growing concern about the continued lack of animation in Daisy’s video. She was discouraged by Daisy's lack of creativity, risk-taking, and what she characterized as Daisy’s “cold,” “lab report”-like SAM video. She said that Daisy's minimally revised video signaled discomfort with both “the material and with SAM.” She was particularly unhappy that Daisy was not using SAM as a tool for looking at the "big picture" that underlies the phenomena of electrical circuits. According to Mary, Daisy was not asking herself what the "rules" were that explained how circuits function.[12]

In this same planning session, I proposed a key change in our procedures. To me, Daisy seemed to be overburdened by having to *simultaneously* learn circuit building principles *and* animation. I suggested that to solve this problem we institute a "physics-free" local session dedicated solely to teaching Daisy how animate with SAM.

In the next "physics-free" local session (11/13/08) I successfully invoked a local problem to motivate Daisy's interest in SAM and to focus her attention on how SAM could be used to make animations. I told Daisy that I needed her help in thinking about how to use SAM to tackle a daily chore at the Learning Lounge: helping younger students with their math homework. Tutoring was a valued practice in the Learning Lounge, and Daisy had always been eager to assume this role. I showed Daisy an animated video I had prepared for this occasion, and presented it as an example of a fun way to use SAM to demonstrate math concepts (see Video 4.1).

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[12] Mary's observations are taken from 11/7/08 planning session transcripts

Video 4.1[13]

Video 4.1: Video used to model animation for Daisy (local session 11/13/09). The video depicts the solution to an arithmetic problem (2 + 3 = 5) through the animated aggregation of a set of two circles with a set of three circles.

After viewing my video, Daisy suggested finding a Learning Lounge student who needed help with their math homework so that we could make a new video. We recruited a sixth grader, Kerri, who was completing a worksheet of word problems. Together the three of us used SAM to make visualizations of a sub-set of these problems. Video 4.2 shows an example of one of the three videos we made. As can be seen when viewing the video, animation is incorporated as a tool for performing a key calculation in the problem (see Video 4.2). The utility of the video for solving the problem, together with the fact that it was made collaboratively, helped me accomplish the objectives I had set out for this non-physics local session: modeling for Daisy how to animate and doing so in a way that satisfied local expectations about helping students with their homework.

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[13] Video accessible via the DVD submitted with the dissertation (file name: chapter-4-video-4.1) or on-line via the Proquest system (file name: 4.1.mov).

Video 4.2[14]

Video 4.2: Video made collaboratively by Daisy, Kerri and me (local session 11/13/09) to represent the word problem: placing posts every 5 ½ ft., how many posts are needed to raise a 33 ft. fence that divides two garden plots? The video successfully incorporates animation as a tool both for visualizing the problem and performing a calculation for solving the problem.

Considered through the lens of mediational strategies, it is clear that up to this point Mary and I were focused on getting Daisy to rethink her tool-use practices with respect to SAM. Translation in this case involved finding a way to meet the expectations that Mary and I had about animation as a learning tool while at the same time respecting local idiocultural norms that prioritized self-direction, giving the learner the freedom to chose the means by which she carries out a task. We were all in agreement about the tool — SAM — but not about how it should be implemented. Daisy's approach conflicted with the one we had assumed she would adopt.

These circumstances made us extra sensitive to an important corollary to the norm of self-direction: if the student has the freedom to shape the course of the learning activity, then she will participate voluntarily. Ordering Daisy to make her videos to our

[14] Video accessible via the DVD submitted with the dissertation (file name: chapter-4-video-4.2) or on-line via the Proquest system (file name: 4.2.mov).

liking might have risked her walking away. Consequently, Mary and I did most of our rearranging of the PLA through the planning sessions, which Daisy did not attend.

Here, we see how the deployment of mediational strategies is reconfigured in a new context. The planning sessions were essentially a form of premeditated backchanneling (vs. the in-the-moment backchanneling that we observed in the parallel circuit telementoring session). These planning sessions were devoted to assessing the progress of the PLA and if necessary, reorganizing activities based on these assessments.

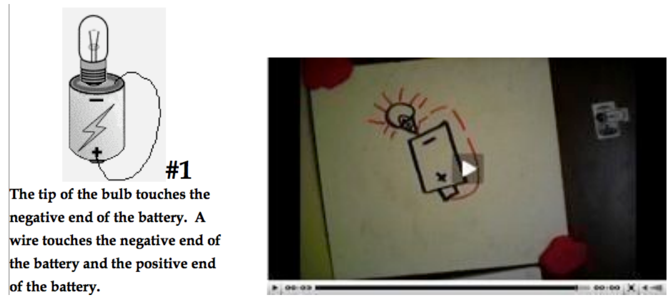
At the same time, translation took place in the planning sessions. The assessments Mary and I made about what had taken place in prior PLA sessions were explicit articulations of our understandings of the logocentric and pragmatic epistemes (vs. the largely in-the-moment, implicit expressions of these epistemes in the telementoring and local sessions).

While our initial efforts to induce Daisy to use animation fell flat (telementoring session, 10/21/08), the “physics-free” local session contributed to the reorganization of Daisy’s tool-use practices in two ways. First, this was the first time Daisy was exposed to the ways SAM could be used to animate. Second, Daisy was shown how SAM could be recruited to meet a local need (math tutoring) that aligned with one of Daisy’s personal goals (working with younger children).

Five days after the “physics-free” session, Daisy and I met with Mary for another telementoring session (11/18/08). Mary took the lead in guiding Daisy to create animated videos of the battery-bulb circuits. At this stage in the project our plan was to have Daisy make six short videos to explain each of the six circuits she’d been asked to evaluate as part of the circuit building session. To emphasize the various uses of SAM and its potential for making explanatory videos, (implementing a strategy we had agreed on in the 11/7/08 planning session), Mary and I asked Daisy to use different modes for each of the short videos in order to articulate her ideas. For example, in one video we told her she could use only cut-out pictures of batteries and bulbs; in another, she could only use drawings; in another, she could only use actual circuit building materials. Also in line with what we had strategized in the 11/7/08 planning session, Mary was the only participant from Colorado. She took the lead in imposing restrictions on the kinds of expressive modes Daisy could use (e.g. drawing, cut-outs, circuit building materials). For my part, I took on the role of Mary's confederate - the local adult who agreed with the proposals made by the expert at a distance. In this way Daisy had little choice but to make her videos in the way that Mary and I had arranged.

Our goal was to limit Daisy's use of written text in order to ensure that she incorporated animations in her videos. The strategy worked: On this day Daisy was able to create two videos with animated circuits (Video 4.3); two days later, in a local session, she produced two others (Video 4.4).

Video 4.3[15]



Video 4.3: Video made by Daisy depicting Circuit 1 (shown left) of the six circuits she assessed during the instructional phase of Sequence 1: Circuit Building. The “growing” wire emerging from the positive end of the battery and moving toward the negative end constitutes Daisy’s first animation.

Video 4.4[16]

Video 4.4: Video made by Daisy depicting Circuit 6 (shown left) of the six circuits she assessed during the instructional phase of Sequence 1: Circuit Building (local session 11/20/09). In addition to repeating the “growing wire” animation from video 4.3, in this video Daisy also animates the bulb to make it appear as it moves on it’s own toward the positive end of the battery.

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[15] Video accessible via the DVD submitted with the dissertation (file name: chapter-4-video-4.3) or on-line via the Proquest system (file name: 4.3.mov).

[16] Video accessible via the DVD submitted with the dissertation (file name: chapter-4-video-4.4) or on-line via the Proquest system (file name: 4.4.mov).

The text/animation tension can be understood as symptomatic of the underlying tension of bringing together the formal-logocentric and informal-pragmatic epistemes. The resolution of this tension may have resolved the “problem” of convincing Daisy to use animation in the activity, but it did not address the fundamental problem of helping Daisy to understand the underlying principles of circuit construction; in other words, we had not helped her to think critically and hypothetically about the material – how to think logocentrically. This was evident in the circuit animations she produced (e.g., Videos 4.3 and 4.4), which identified circuits that did and did not work, but did not say *why*. In other words, Daisy was able to *describe* the circuits through alternative means, but she could not *explain* their operation. This leads us to an examination of the *Description-Explanation Tension.*

3.2 Encountering and “Resolving” the Description-Explanation Tension

From Daisy’s perspective, the lack of explanation in her videos was a consequence of the very strategy that Mary and I implemented to help her incorporate animations in her videos: Daisy argued that requiring her to only use drawings and cut-outs, with no written phrases or sentences, meant that she could not make her videos explanatory. Daisy, however, had a tool in her toolkit for resolving his dilemma.

Recall that in response to our first attempt to motivate Daisy to incorporate animations in her videos (telementoring session, 10/21/08), Daisy added a voice-over track to her lab-report style video in which she simply read the text shown in each of the “slides.” She had effectively hijacked the use of voice-over in order to sidestep the expectation that she animate. Now voice-over stood to benefit her because she could presumably speak the text that she would have included in each of her video frames and thus include explanation in her videos.

When Daisy tried this new voice-over approach (local session 11/25/08) she was able to complete the voice-over track, but she struggled for over an hour to do it. One problem was that she had trouble figuring out *what* to say and remembering *when* to say it. I suggested she write herself a script. This advice did not contradict the requirement we had put in place earlier that Daisy avoid using text. That requirement was specific to using text in place of animation in the video itself. The voice-over script she ultimately wrote and recorded did not address the underlying rules of circuit construction; instead it mainly described what was being depicted from one frame to the next.

Another problem emerged: Daisy was visibly self-conscious of her performance. I had allowed two other adults to sit in and watch as Daisy worked on her video. As this voice-over session progressed, it became obvious that having other adults looking over Daisy's shoulder and asking her questions only added to Daisy's struggles. This was an instance in which I had translated myself into a corner. Inviting more participants into the activity fit Learning Lounge norms, but those norms were not helpful in this circumstance.

In the next planning session (12/3/08) I proposed to Mary that I make arrangements for Daisy to work on her own, and Mary agreed. In the next local session (12/4/08), instead of hovering around Daisy as she prepared her voice-overs, I ran maintenance on other computers in the room. This allowed me to remain with Daisy - a

Learning Lounge rule (no student could be in the tech room unsupervised) - monitoring with enough “distance” to give Daisy the sense of independence I thought she needed to work through the task.

In this session, Daisy significantly changed her video production approach. She recruited Rubi, a fifth grader, to help her with the voice-overs, and instead of writing a voice-over script as she had in the prior local session, Daisy improvised a new technique for creating the voice-over “text.” Rubi was invited to watch the video while Daisy lead a discussion about what they were watching, maneuvering the dialogue in ways that appeared designed to get Rubi to elicit explanations from Daisy. Daisy audio recorded the ensuing “conversation” and then synched the recording with the images in the video.

Although this approach was a clever strategy for “writing” and recording voice-overs, it did not produce the kind of explanation that Mary and I were seeking. The result was similar to the voice-over Daisy previously produced: mainly description without discussion of underlying principles. This time, however, as Daisy struggled to articulate the principles to Rubi, Daisy’s difficulties grasping these principles were exposed (Video 4.6, 2:52 − 4:10). In the video, as Daisy goads Rubi into asking her why the light bulb doesn’t light, Daisy stumbles. She appears to know that particular elements in the circuit should be in contact with one another (“the light bulb has to touch the battery”), but her understanding is limited. I can be heard translating in the background, trying to both bail her out and to guide her toward a more precise response (“What part of the light bulb does it have to touch?”).

Over the course of the three remaining local sessions, Daisy went on to use this voice-over co-authoring technique, recruiting two other elementary school girls to help her add voice-overs to the animations she created for the remaining five circuits. This brought her to completion of the SAM video she was required to produce for Sequence 1 of the curriculum (Video 4.6). Even a cursory inspection of Daisy's final video reveals that at no point did she address why the circuits did or did not work. Instead, she created a collection of playful conversations between herself and her voice-over co-authors describing what unfolds from one frame to the next.

Video 4.5[17]

Video 4.5: Video made by Daisy as her final assignment for Sequence 1: Circuit Building.

Daisy's creation of the voice-over co-authoring did not resolve the description-explanation tension, nor did it help her explain her ideas about why the circuits did or did not work. However, Daisy had become quite nimble at using SAM, and clearly enjoyed the attention she got from being a local SAM expert. This was in keeping with her persona at the Learning Lounge. She was one of the few teenagers who openly expressed

[17] Video accessible via the DVD submitted with the dissertation (file name: chapter-4-video-4.5) or on-line via the Proquest system (file name: 4.5.mov).

an interest in science, who participated in all of the UCSD-led projects in the Learning Lounge, and who regularly and willingly played surrogate caregiver for the younger students. The young co-authors Daisy recruited were particularly captivated by the animations Daisy had made, and Daisy relished being able to show them how to use SAM to make their own.

The voice-over co-author technique was in line with local expectations about the informal organization of activities. It was evidence that Daisy was taking ownership of her learning and doing so in a way that promoted mixed-age activities that incorporated varieties of media to encourage explanatory communication (Cole & The Distributed Literacy Consortium, 2006). In recruiting young girls to help her with her videos, Daisy not only taught them how to use SAM, she also occasioned situations where she demonstrated some of what she had learned in the telementoring sessions. For example, following the session in which Daisy first recruited Rubi (12/9/08), Rubi returned and Daisy initiated an interaction, which she videotaped, in which she easily showed Rubi how to build a battery/bulb circuit.

Clearly there were many positive aspects to the way that Daisy translated SAM tool-use mediation to fit with local goals. For this reason, and because of the boost in self-confidence to Daisy, I was not initially anxious about the lack of substantive explanation in Daisy's videos. Furthermore, I assumed, correctly, that the planned group discussion session (Chapter 2, section 5.1 *Initial Design*) would give us a chance to address any gaps in Daisy's understanding of circuits. Neither did Mary express concern at this time. In fact, in the first planning session of the following sequence (2/2/09) she spoke positively about the voice-over co-authoring technique.[18] The failure to resolve the description-explanation tension was something that, for the moment, we tolerated.

As I will show in the remainder of this chapter, Daisy's voice-over co-authoring technique would force us to restructure the activity in terms of a practical project to electrically wire a house. This transformation is clearly visible in the implementation of the topic sequence (conductivity) that followed.

4. Disruption Cluster 2 - Local Goals

The tacit and explicit approval that Mary and I gave to Daisy's co-author voice-over technique had consequences for the way activities unfolded in Sequence 2. Daisy was now seen as ready to produce SAM videos "on her own" without the supervision of staff from Colorado. She went on to recruit Aisha, a fourth grader, who did not, however, acquiesce to Daisy's expectation that she perform the role of obedient student. Aisha's resistance further highlighted Daisy's pragmatic approach to using SAM, and the ways this approach enabled her avoidance of the kind of logocentric thinking we were attempting to foster. I, in turn, had to work harder to align Colorado's goals with local cultural norms and with Daisy's own goals.

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[18] It was during this planning session that Tom was formally introduced to the project. Mary explained to Tom that he did not have to worry about making the videos with Daisy. She said I could take care of this and added that I had a method that involved having Daisy "explain things to other kids . . . so that she has some way to organize her thoughts." (2/2/09 field note/log). That Mary trusted me to supervise Daisy with video production was something she conveyed early in the project. For example, in one of the early planning sessions (10/10/08) when discussing how to organize the video production phase of each curricular sequence, Mary deferred to me ("I'm sure you'll be much better at this then we are"), referring to me and my lab mates as "the experts at doing documentary" (10/10/08, field note/log planning session).

The tensions produced by these circumstances led to the series of disruptions that I refer to here as the Local Goals Disruption Cluster (Figure 4.5). These disruptions centered around actual and potential challenges to Daisy's authority as a local SAM and circuit expert. Daisy was caught between logocentric and pragmatic epistemes in a manner that shows how her local status as both caregiver to the children and an aspiring engineer were put at risk when she was unable to engage with the PLA content in ways that met the expectations of either our physicist colleagues or Aisha. I was put in a position of trying to help Daisy save face while at the same time helping to facilitate authentic opportunities to learn, for both her and Aisha.

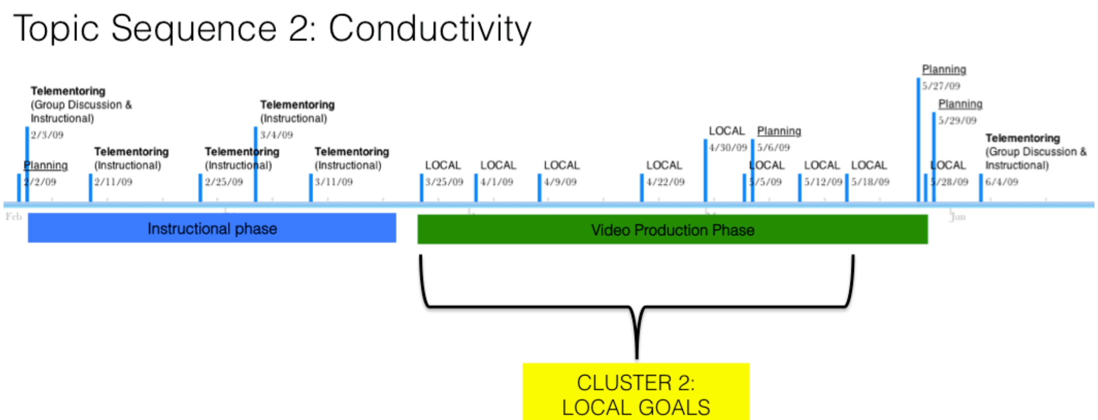


Figure 4.6: Timeline of PLA sessions in which the second Sequence of the curriculum (Conductivity) was implemented. The bracket indicates the subset of sessions that constituted the Local Goals Disturbance Cluster.

4.1 Encountering and Resolving the Authority Tensions

We asked Daisy to make two videos for Sequence 2 on conductivity. Given the difficulties Daisy had with some of the topics covered in Sequence 1, we asked that her first video review relevant topics, including the internal architecture and function of a light bulb. I refer to this video as the *light bulb* video. For the second video, we asked her to explain all she had learned about conductivity. For reasons that will become clear, I refer to this video as the *multiple choice* video.

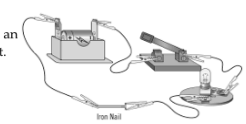
In line with the pattern she had developed in Topic Sequence 1, Daisy first created the visual elements for each video and used these visuals to motivate the co-authored voice-over sessions with younger Learning Lounge students. After completing the visuals for the *light bulb* video, Daisy decided to recruit Aisha to help her lay down the voice-over track.

As noted in Chapter 2, Aisha was (and is) among the most outgoing, confident, and argumentative of the Learning Lounge youth. In the course of being prepped by Daisy for the voice-overs, Aisha raised questions about the way that Daisy depicted the flow of electricity into the bulb. This challenge led to a moment when, to Aisha's obvious delight, I pointed out a mistake in Daisy's representation of electrical flow. Aisha's undermining of Daisy's authority as a circuit expert played an important role in changing Daisy's subsequent SAM-based tool-use. In addition to making videos to establish her authority, Daisy would now make videos to maintain her authority.

Both to save face and in anticipation of further challenges from Aisha, Daisy again altered her tool-use approach with SAM. This effort was crystalized in Daisy's *multiple choice* video, which she worked on in the 4/22/09 local session. For this video Daisy adapted the exercises from her latter telementoring sessions when she had been taught to build a circuit to test the conductivity of a variety of objects she had gathered at home, including a silver necklace, wood, glass, and a nail (Figure 4.6). First, she filmed all of the objects that she had initially gathered. Next she came up with a pair of multiple choice questions that asked the audience to determine which of the items “will light [a bulb]” (question 1) and which “do not conduct electricity” (question 2). Minutes into the session Daisy made it clear that she was making the video in order to administer it as a test to her elementary school girl recruits. Tellingly, she identified Aisha by name as one of her recruits.

Experiment #2.1 In the previous experiment you used copper wires to connect the battery and bulb together. (At first you just used bare copper wires. Then, to make it easier to connect things, you used special copper wires with a surrounding plastic sheath and metallic alligator clips at its ends.) Does it make a difference what kinds of materials you use to connect the battery with the bulb? Will anything work to allow the bulb to light? You will try to answer those questions in this experiment.

In the circuit drawing, notice that an iron nail is in the path of the circuit.



For each object in the following table, say if you think the bulb will light.

Table 2.1 Prediction of materials that allow the bulb to light

Item and material	Does the bulb light? (YES or NO)
iron nail	
wood stick	
glass rod	
aluminum foil	
copper wire	
steel nut	

Figure 4.7: Excerpt from the worksheet Daisy used during the instructional phase of Topic Sequence 2: Conductivity. In the exercise shown, the reader is introduced to a circuit that can be used to test the conductivity of different objects. Table 2.1 prompts the reader to predict wether inclusion of each of the listed objects will light the bulb in the circuit. In a later exercise, Daisy built the circuit and tested a variety of materials she had gathered from home.

On the basis of on my experiences with Daisy and Aisha, I guessed, that Daisy was gearing up to use the video, not for friendly collaboration, as she had done before, but as an occasion to shame Aisha. Aisha, though, had proven a worthy adversary, so I intervened to make sure that Daisy did not just ask questions and provide answers. I wanted her to explain why she thought each of the objects did or did not conduct electricity. This was an instance of translation. By helping Daisy to take a logocentric approach to thinking and talking about her video content I was addressing multiple goals: Colorado's interest in helping Daisy think logocentrically, local expectations that this learning take place collectively and through multiple media, and Daisy's interest in successfully taking on Aisha.

My intervention centered on Daisy's second multiple choice question in which two of the answer choices each contained two objects (answer "d", a silver necklace and a wooden plaque, and answer "e", a carabiner and a silver necklace; Figure 4.8 B). I suggested that she could use the video as an opportunity to show Aisha how to test the conductivity of the different objects, including using actual circuit building materials to construct circuits incorporating two different objects.

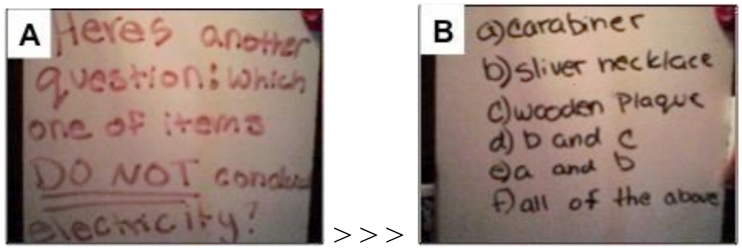


Figure 4.8: Consecutive stills from Daisy's multiple choice video. Still A shows the question. Still B shows the answer choices. Choice "c" (wooden plaque) is the obvious correct answer; however, choice "d" which includes one item that does conduct electricity (silver necklace) and one that does not (wooden plaque) is ambiguous.

Moments later when Daisy was finalizing the frame displaying the different answer choices (Figure 4.8 B) she became confused. She went from believing that there was more than one answer to thinking that there was only one (C wooden plaque). Apparently this was because she had forgotten the question she had originally posed (Figure 4.8 A). Talking to herself out loud she said: "I didn't even know what I was asking." Then she re-read her original question (Figure 4.8 A), realized her confusion ("oh 'does NOT conduct electricity'"), and re-thought her answer (" There's only one answer, 'C' ")

Here we have another example of the reconfiguration of mediational strategies in different contexts. In this case, I am enacting translation by simultaneously helping Daisy pursue her personal goals related to identity work, while channeling this work in ways that would expose her to logocentric thinking and communication. Taking into account Daisy's interest in challenging Aisha and seeking to create an opportunity for Daisy and Aisha to engage in authentic co-examination and co-construction of circuits, I suggested that there could actually be two answers. Choice "C" (wooden plaque) was the obvious answer. However if one considered the answer choices in terms of objects incorporated into a single circuit, choice "D" (silver necklace and wooden plaque) would also be legitimate. I convinced Daisy that she could turn her convoluted answer choices into a teaching opportunity: she could use actual circuit-building materials to teach Aisha the difference between a circuit that contained both the necklace and the plaque and two individual circuits containing one object each. This opportunity would not only promote local goals regarding collective learning activities and allow Daisy to pursue self-image work; it also had the potential of occasioning logocentrically-oriented interactions between Daisy and Aisha.

At the same time, reframing the ambiguous multiple choice question accomplished the work of backchanneling - maintaining interpersonal harmony - but without the collusion in the examples of backchanneling we observed in telementoring (the parallel circuit session) and planning sessions. Similar to the kind of backchanneling observed in the events of the Text/Animation Tension, my intervention was intended to keep Daisy from recognizing that I was in fact intervening. Again, to ensure Daisy's voluntary participation it was often important to make her feel like she was in charge and that I wasn't teaching her. This was accomplished by showing Daisy how her multiple choice question could occasion an opportunity for her to teach Aisha. In this case local idiocultural expectations served as cover for my intervention. Using the ambiguous multiple choice question to occasion a teaching interaction with Aisha satisfied both local norms about the mixed-age organization of activities *and* Daisy's interest in challenging Aisha. Daisy was on board.

My efforts to shape how Daisy used the *multiple choice* video extended beyond the session where she came up with the idea for the video. In the following local session (4/30/09) I made a point of sitting Daisy down before Aisha arrived and working with her to imagine how she would explain the answers to Aisha. I wanted to make sure that Daisy could still make sense of the circuit implied by the question (hereafter called the silver/wood circuit). I also wanted to encourage her to include animations in what was so far a text-only video.

When I sat with Daisy to prep her for teaching Aisha, I first asked her to draw a silver/wood circuit. Then I asked her to use the drawing to explain to me why the circuit didn't work (Figure 4.9). After some discussion, Daisy, both verbally and through modifications to the circuit drawing, explained that the presence of the wood in the circuit would prevent the circuit from being "complete" because it would act as a barrier preventing the electricity from flowing past.

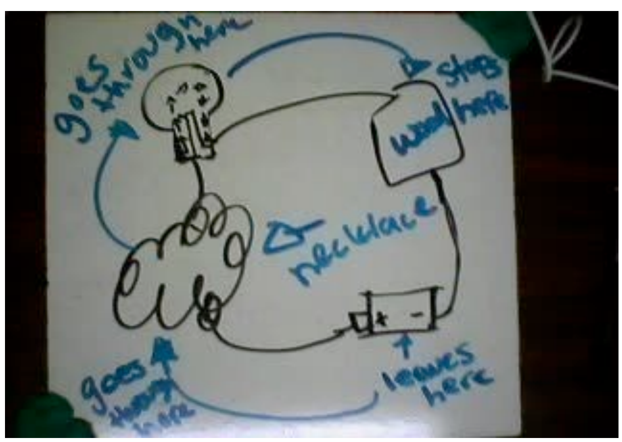


Figure 4.9: The image that Daisy drew when I prepped her to teach Aisha about the silver/wood circuit (local session, 5/5/09).

When Daisy finally showed Aisha the *multiple choice* video (local session 5/5/09) Aisha was her familiar skeptical self. Aisha did not believe Daisy when she told her that all of the objects listed in the first question (aluminum, iron nail, and copper wire) would conduct electricity. Daisy was prepared for this. With all of the relevant objects (including a piece of wood and a silver necklace) and circuit building materials at the ready, she proceeded to show Aisha how to build a circuit to test each object. The interactions that followed occasioned talk and experiments among the three of us in which we discussed our intuitions about the relationship between the material properties of the objects and whether or not these objects did or did not conduct electricity. We spent the rest of the session testing and discussing circuits that contained the individual objects, but did not get so far as to discuss circuits with multiple objects in them, so the silver/wood circuit never came up.

It wasn't until Daisy began adding voice-overs to the *multiple choice* video (local session 5/18/13) that the topic of the silver/wood circuit arose. At this stage in its production, the *multiple choice* video revealed little about Daisy's understanding of conductivity. Here again translation played a role. I was mindful of getting Daisy and Aisha to demonstrate their understanding from a logocentric perspective so I encouraged them to add frames to the video that explained why a silver/wood circuit would not work (i.e. clarifying the ambiguity of the second multiple choice question; Figure 4.8). Having saved a digital image of the silver/wood circuit drawing that she made in preparation for teaching Aisha (Figure 4.9) Daisy cleverly added the picture at the end of the video. She then used the drawing to explain to Aisha her idea that the wood acted as a barrier preventing the electricity from flowing past. Following this explanation she showed Aisha the drawing, asked her questions to get her to explain the diagram, audio recorded this dialogue, and synchronized it with the picture of the drawing in the video. Through this performance Daisy effectively got Aisha to ventriloquate the "wood-as-a-barrier" explanation that Daisy had posited earlier.

As the sequence on conductivity came to a close, I felt that, overall, things had gone well. Daisy had used SAM in ways that helped meet local goals, the goals of our partners in Colorado, and Daisy's personal goals. The fact that Daisy did not include animations in the multiple choice video was not something I found problematic. Recall that originally the role of SAM in the PLA was as a medium for students to explain to others what they had learned from the telementoring sessions. Both in the written instructions of the curriculum ("make a documentary about what you learned") and in the way that the video-production activity was presented to Daisy (as an exercise in explaining what she had learned to someone who completely unfamiliar with the physics material) the implication was that the SAM videos should function as stand-alone lessons. From my perspective, having witnessed the variety of collaborative and teaching activities that Daisy's video-making process engendered, Daisy was taking this a step further: she was using SAM to occasion situations in which she could perform these lessons herself. In an important sense, Daisy was meeting the original goal of explaining to others what she had learned. From my perspective, and from the perspective of local norms, Daisy was doing a great job. As we will see in the third and final Disruption Cluster, Mary in Colorado did not agree.

5. Disruption Cluster 3 - Pedagogical Clash

In this final disruption cluster — the Pedagogical Cluster (Figure 4.10) — the logocentric-pragmatic tensions of the prior cluster moved from being implicitly manifest in the ways that Daisy and I attempted to shape the uses of SAM to being explicit in confrontations between myself and Mary over the ways instruction in the PLA should proceed. These tensions began to surface as Sequence 2 on conductivity was coming to an end. I convened a planning session (5/6/09) with Mary in anticipation of upcoming telementoring sessions. Red flags were raised for Mary when I described Aisha's unexpected participation as occasioning authentic learning opportunities for Daisy. Mary saw things differently. At stake for her was the integrity of the curriculum, which she described as exploring circuits in "an order that is . . . natural." From Mary's perspective, Aisha's involvement disrupted this order.

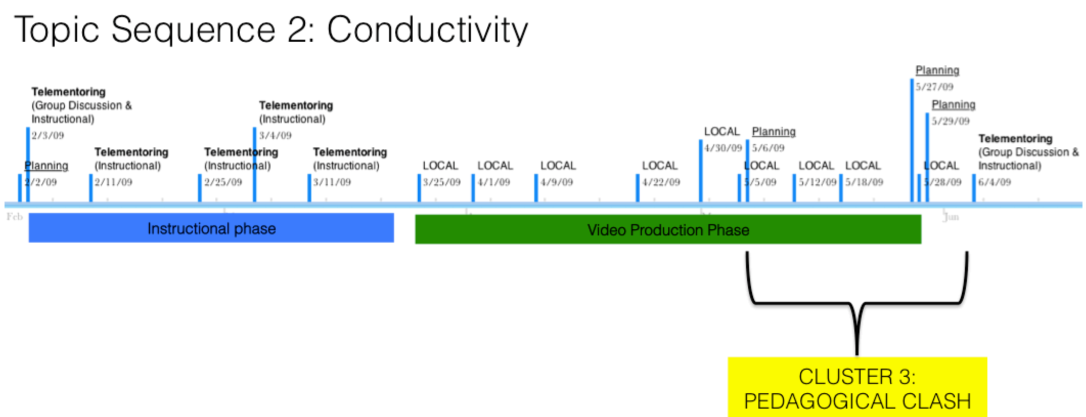


Figure 4.10: Timeline of PLA sessions in which the second Sequence of the curriculum (Conductivity) was implemented. The bracket indicates the subset of sessions that constituted the Pedagogical Clash Disturbance Cluster.

Mary's concerns about Aisha's involvement were confirmed when she reviewed Daisy's *light bulb* and *multiple choice* videos. The teacher-student role play that structured the videos was for Mary an obstacle to Daisy's learning. At the same time, Mary saw the videos as evidence that Daisy and Aisha were mutually reinforcing each other's misconceptions about electrical flow in circuits.

I, on the other hand, appreciated the videos and the history of interactions that had produced them for the actual and potential learning opportunities that they created. What's more, I reasoned, if Daisy had misconceptions about the content, wasn't the point for us to use the videos to discuss and clarify these?

In what follows I look closely at the planning session that immediately followed Mary's first viewing of Daisy's videos (5/27/09 planning session). It was then that the underlying tensions that had been brewing from the beginning boiled over, leading Mary and me to articulate the logocentric and pragmatic epistemes that were at the heart of the problem. The resulting crisis proved to be the turning point, discussed at the beginning of this chapter, that led to the consequential restructuring of the PLA, from an activity centrally organized around logocentric concerns to one that was focused on pragmatic approaches to teaching and learning physics.

5.1 Encountering and Resolving the Pedagogical Tensions

Mary's strong reaction to Daisy's videos took me by surprise. She was "bothered" and "disturbed" by the fact that Daisy was creating very "school-like" videos in which she was being "too authoritative and not exploratory enough." Mary was afraid that things were "getting out of control," and she told me I needed to "make [Daisy] stop working with the [elementary school girls]," (transcript, 5/27/09 planning session).

I felt Mary was holding me responsible for what she judged to be a substandard outcome of the PLA. I immediately launched into a defense of the Learning Lounge idioculture. I argued that we wanted Daisy to "get into situations where she genuinely explains what she understands," (transcript, 5/27/09 planning session). For me, Daisy's teacher-student role playing events were not only occasions of real learning but were also creative acts for Daisy. I explained this to Mary, and added that this kind of role play was central to Daisy's local identity as a surrogate caregiver for the younger children. Mary did not see things the same way:

> "[Daisy's] perpetuating this authoritative idea . . . She is just being you [Robert] in the sense that you represent to her the one what knows stuff . . . as opposed to understanding. You know a thing that she doesn't know and she's going to pretend she knows by acting it out with [Aisha] . . . I find that fairly disturbing . . . she's found a device for hiding behind what she really thinks. I think that's a problem . . . I think this is slowing her down." (Transcript 5/27/09 planning session)

I asked Mary to clarify what she meant by "slowing her down": "Slowing her down towards what? . . . Maybe we're not calling it a 'right or wrong' understanding of physics but what kind of an understanding of physics?" Mary responded:

> "I feel like what we should be achieving with her - forget the science for a second, forget the content - What I want her to get out of this is . . . [adopting Daisy's voice] 'I can figure this out for myself by figuring it out.' It's not that there's authoritative right and wrong answer. I want her to come to a natural, exploratory relationship to science, not a school, right or wrong answer, here's a multiple choice test – I was really disturbed when I saw that. That really bothered me. . . If they get the content . . . great, but I don't consider that to be the primary activity. The primary activity here is understanding what it means to do science and she is so not doing that. . . the more that she perpetuates this authoritative role the farther she gets from that objective," (Transcript 5/27/09 planning session).

Sensing that all of this would not sit well with Daisy, I reminded Mary that Daisy consistently had a hard time admitting being wrong. Mary saw this as something to take advantage of: "Great! That needs to be confronted! If we get her to do that, that is what a scientist does." She proposed confronting Daisy by requiring her to explain each of six circuits she was shown in Sequence 1, certain that this would make public Daisy's failures in understanding. In making this proposal Mary described how she envisioned Daisy should go about building and evaluating these circuits:

> "First you say what do you think, then you say why you think it, and the reason why you do that is so that you have an understanding of what your current model is. . . I wouldn't use these words with her, but you know what I mean. You have a current model in your head . . . now you try the experiment and your model doesn't map so you have to change your model . . . If that's not OK with her, we're not doing anything with her really . . . and she will never succeed at science until she's got that attitude . . . I think it's essential to address it . . . She needs to change her paradigm of how she's learning this, and we need to not reinforce it by letting her be the authoritative figure with these kids," (transcript 5/27/09 planning session).

Here we are exposed to a key assumption that is at the heart of the tension between the logocentric and pragmatic epistemes, the assumption that the learner comes to the problems with a "working model," with knowledge of "why the thing works."

I saw Mary's proposal to confront Daisy as a threat to the continuation of the project. I was sure it would lead Daisy to drop out. The idea of confronting Daisy involved not just asking Daisy to review her own work in a more principled way. It would also expose her lack of understanding of physics, and undermine her identity as teacher and helper of younger girls. Sensing my hesitation Mary asked if I thought Daisy had "a social reason why it might not go well if we [confronted her] directly?" I explained that I did not "want to turn [Daisy] off of the activity," given that I had been supportive of her video-production approach. Direct confrontation would put me in a position where I would effectively be telling Daisy that "all the stuff you've been doing is bad." Instead, I argued, we should address the question of Daisy's video-production technique by way of the videos themselves. This would allow us to indirectly critique her technique and correct her misconceptions while minimizing the risk of threatening her identity.[19]

In the end, Mary agreed to go along with the video-mediated approach, but she qualified this agreement. She expressed concern that, even by going the video route, Daisy would still feel embarrassed, and that "just because we're afraid . . . that she's going to be hurt by this is not a reason not to proceed to try to get at this." Mary did not specify how she was going to use the videos in the discussion with Daisy: "It will depend on what she says back as to what I think of to do next . . . where I get my ideas is on the fly," (transcript 5/27/09 planning session).

I left this discussion concerned that the next telementoring session would be a disaster, and afraid that Daisy would walk away from the project. I immediately met with my advisor who, after listening to my concerns, placed a call to Mary's supervisor, Jonah. Because Jonah was not available I left my advisor's office with no idea about how the project would proceed.

The following day I learned about one of the most consequential pieces of backchanneling and translation in the PLA when Mary emailed to let me know that Jonah had asked her to drop the SAM curriculum. In its place Daisy was asked to build a scale model of a house, and use the circuit-building materials she had used in the past to wire

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[19] Here I was following one of the rationale that the designers of SAM put forth for using the software as a physics education tool. They argue that in situations in which SAM is used to assess students' understandings and beliefs about physics, "critiques of the student's own beliefs are less personal when the critique is centered on an object such as the movie," (Church, Gravel, Rogers, 2007, p. 862)

the model so that each of its rooms could be lit independently. Jonah and my advisor, responding to my concerns that Daisy was at the point of quitting, suggested the change in the hope that this task would re-engage Daisy and allow the PLA to continue.

A week later, Mary, Tom, and I held a planning session in which we were to discuss how we would implement the House Wiring Project. “We” as it turned out, would be just Tom and me. Mary told us that Tom and I would now be responsible for running the activity. She did not hide the fact that she thought the house wiring activity would not work as a replacement for her curriculum. And she also implicitly and explicitly accused Tom and me of being too permissive with Daisy and that this had been detrimental to her learning. As it turned out, this was Mary’s last action in the PLA.

6. Mediational Strategies Across Sessions and Time

Our examination of meditational strategies from the start of the PLA and across session types throws into relief the way that changes in social configurations over time impacted the deployment of mediational strategies and thus, how logocentric-pragmatic tensions impacted the ongoing organization of the PLA.

Who participated in the sessions mattered. Planning sessions only involved me and our partners in Colorado. As a result, a great deal of backchanneling took place that focused on integrating (translating) logocentric practices into PLA activities in ways that did not threaten Daisy’s voluntary participation. Translation in this context involved coming to consensus about both preemptive and ad hoc interventions for addressing logocentric-pragmatic conflicts that emerged in the week-to-week contingencies at the

Learning Lounge. Because we needed to carefully coordinate Daisy's activities, the process of building consensus highlighted the different theoretical and pedagogical commitments on either side of the fiber optic cable more explicitly than was observed in the telementoring and local sessions.

On the other hand, local sessions only involved me, Daisy, and other Learning Lounge students. Without our Colorado partners there actively regulating what we were doing, Daisy had relatively more freedom to pursue her goals. Compared to the planning and telementoring sessions, my role as the mediator who was supposed to see that all went well "on the ground" shifted. I became a "proxy" for Colorado, working to keep the goals of teaching physics in our local activities, while at the same time attempting to arrange these activities in ways that met Daisy's interests. Translation under these circumstances was a process of guiding Daisy's pragmatically grounded use of SAM in ways that allowed our partners in Colorado to both appreciate the many interesting science-oriented activities that Daisy and her recruits were engaging in off-line, and to assess the learning unfolded in these activities. In other words, translation locally was a process of fitting the logocentric into the local in subtle enough ways to keep Daisy participating and to make what she was learning visible to Colorado.

Finally, we need to consider the impact on the ongoing organization of the PLA of changes in the distribution and number of PLA sessions over time. Figure 4.11 compares these distributions and numbers between the implementation of the first and second topic sequences in which the "Learning the Tool" and "Local Goals" disruption clusters occurred, respectively. Notice that in the implementation of the first topic sequence, telementoring and local/video production sessions tended mostly to follow one another. This reflects the fact that Mary and I (and Daisy, though not it the same way) were dealing with the consequences of the logocentric-pragmatic tension. We were “learning the tool”: when Daisy made an unexpected movie in a local session, we had to hold a telementoring session to “correct” the movie, and so on, until Daisy came up with the satisficing (Simon, 1959) voice-over co-author technique.

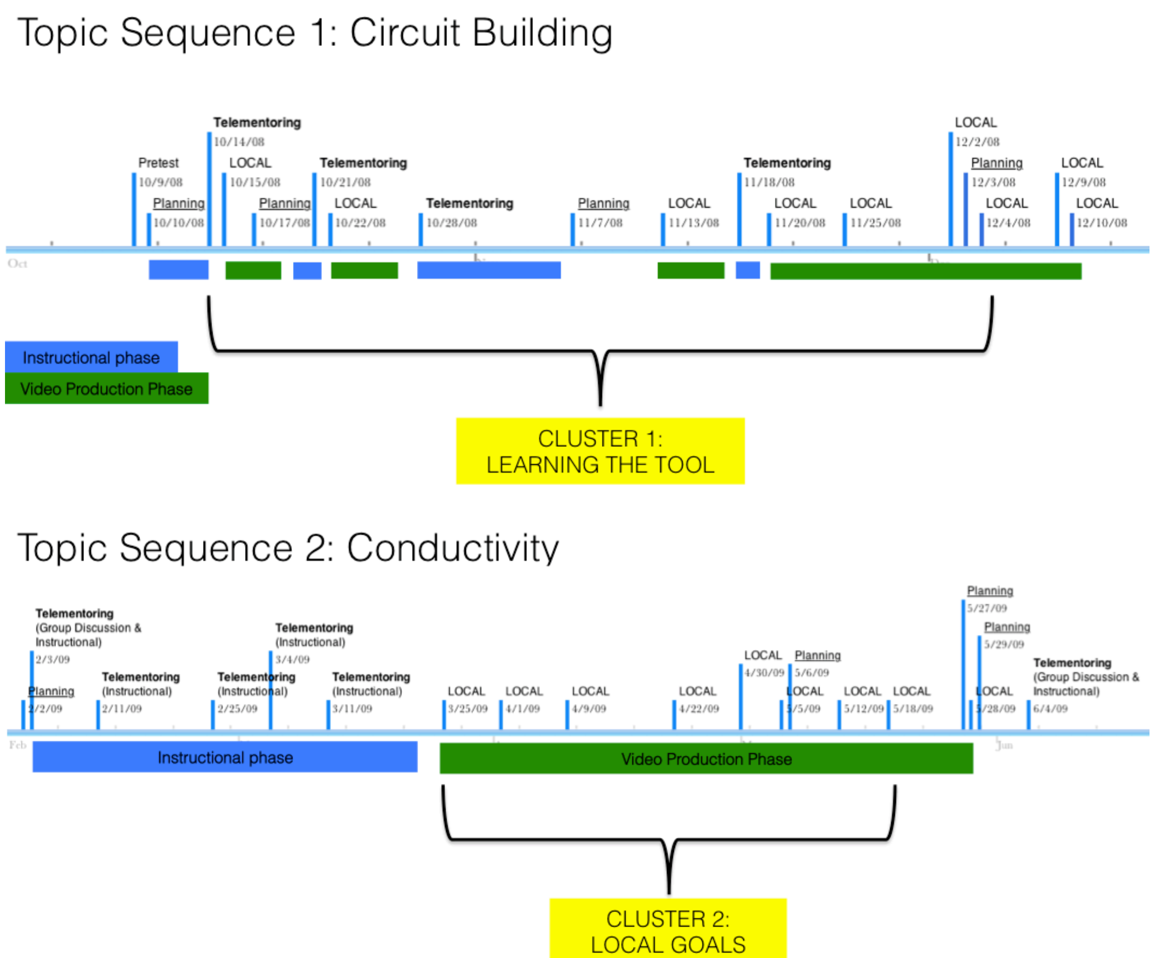

Figure 4.11: A comparison of the distribution and number of PLA sessions between the implementation of the first topic sequence on Circuit Building (in which the “Learning the Tool” disturbance cluster unfolded) and the second topic sequence on Conductivity (in which the local goals disturbance cluster unfolded).

It was in part because the voice-over co-author technique was "good enough" that we see such a significant change in the distribution and number of PLA sessions in the implementation of the second topic sequence (Figure, 4.11, "Topic Sequence 2: Conductivity"). With Mary giving Daisy and me her blessing to work on the SAM videos on our own, there is no longer a need for telementoring interventions to correct the work of the local/video production sessions. As a result, the telementoring sessions are clustered at the beginning of the sequence, the local/video production sessions are clustered at the end, and there are no planning sessions in the middle. Significantly, the number of local/video production sessions (9) is nearly double that of the telementoring sessions (5). This reflects the overall pattern in the PLA where 67% of the PLA session (33/46) were local/video production sessions.

The overall increase in the number of local sessions is an important detail to consider as we make our way into a discussion of theory and policy in the final chapter. As discussed in the opening chapter of the dissertation, at the time that it was implemented, the PLA represented the state-of-the art in providing learners with access to the content, technologies and experts for learning STEM. The significant amount of time that Daisy spent engaging with content and technologies outside the purview of the experts raises questions about the role of both experts and "non-experts" for facilitating learning in activities like the PLA. Similarly, we need to think carefully about how to help learners make meaningful connections between the informal, everyday "doing" of science that happens in after-school settings and the more formal scientific discourses and practices that these learners encounter at school or in their interactions with experts.

Having described the different ways that mediational strategies were deployed over the course of the PLA and in all manner of PLA sessions, we are now in a position to interpret more richly the PLA overall, to evaluate the “success” of the parallel circuit session that instigated our retrospective look at the PLA project, and to raise questions about what all this means for theory and practice. In the following chapter I will turn my attention to these tasks. In doing so I will highlight the educational challenges of mixing formal and informal education, challenges that need to be considered when designing such programs and when making public policy.

CHAPTER 5: University-Community After-school Collaborations and the Mediation of the Formal/Informal Divide: Implications and Recommendations

1. Introduction

The focus of this dissertation has been on characterizing the two forms of education embodied in the overall PLA system — formal/ schooled/prescribed vs. the informal/functional/negotiable/activity-bound; based on what I have called the logocentric and pragmatic epistemes — and understanding the processes by which the tensions produced in the combination of these two forms of knowledge are resolved. I initially framed this problem by asking:

> *What local mediational strategies emerge when formal knowledge and corresponding pedagogies are imported into the idioculture of after school settings, with their "not school" practices and their informal pedagogies?*

The approach I took to answering this question produced a narrative of the PLA that began near the end of the project with a moment of celebration of success that was analyzed in microgenetic detail. My account then flashed back to the beginning of the project and retraced events at a more "meso" level of analysis in order to articulate the developmental history needed to make sense of the successful parallel circuit session. In this chapter I tell this story again, but this time I tell it "forward" along the path to the celebration of success. I do this in order to highlight aspects of this history that address broader questions, raised at the beginning of this dissertation, about the relationship between mediational strategies and opportunities to learn, and about the implications of my research for efforts to design and implement technologically-driven, U-C Links, after-school learning activities.

Narrating the path to Daisy's success in chronological order will deepen our understanding of how the conflict between the logocentric and pragmatic epistemes changed over the course of the project. I examine these changes in order to throw into relief, first, the different ways that educators, learners, and researchers understand focal educational tools and the purposes to which these tools are applied, and second, to identify the consequences of these differences for designing and implementing academic instruction in after-school settings using new digital technologies.

Then I will turn to a discussion of the developmental history of the three mediational strategies that were identified in Chapter Three, translation, backchanneling, and tool use. My focus will be on the relationship of mutual transformation between the epistemes and the mediational strategies. Here I will draw on my experience as a local mediator to highlight how as our understanding of the dominant episteme changed so did our understanding of the strategies deployed to mediate between the two epistemes. My role — both as the only participant who was involved in all three categories of PLA session, and as someone with strong historical connections with Daisy and the Learning Lounge — gave me a unique perspective on the linkage of changes between epistemes and mediational strategies.

I will conclude the chapter by discussing implications and recommendations stemming from my research, giving rise to a number of questions: How should we re-think “Daisy’s success” at building a parallel circuit? How should we evaluate the success of the PLA as a functional, historically developing teaching-learning system? What does the path to success and the many difficulties along the way, tell us about the widespread hopes and policy recommendations promulgated in government documents about the use of the internet to bring science, technology, engineering, and math (STEM) education into the after school hours?

2. Reviewing the Path to Success

In this second section I narrate in chronological order the events that ended with the successful parallel circuit session, in order to highlight the developmental transitions that led to the consequential restructuring of the PLA.

2.1 In the Beginning

One of the original research goals of the PLA was to investigate the viability of SAM as a tool for teaching physics. The focus on SAM derived from, among other things, its presumed appeal to young students who were assumed to be “digital natives”, and its usefulness for creating visual representations to supplement other representations that youth learning science generally work with. These expectations were not capricious. SAM had a track record of success in classroom settings where physics teachers incorporated it in lessons specifically designed to draw on its animation affordances

(Church, Gravel & Rogers, 2007). As noted in Chapter Two, we also had succeeded in using SAM in a telementoring context to teach a Learning Lounge fifth grader about constant speed and acceleration (Mayhew & Finkelstein, 2008). It was this success that led to the design and implementation of the electronic circuits version of the PLA.

This initial success had generated high expectations. It never occurred to us that SAM could be used as a text-based power point presentation that actually avoided the "creative" use that we and SAM's designers imagined for it. As a result, we were taken by surprise when Daisy disrupted Mary's carefully crafted curriculum by using SAM as a text-only, descriptive tool.

2.2 The First Developmental Reorganization

As my account in Chapter 4 illustrated, Daisy effectively defended her use of SAM by appealing to the need to write things down in order to explain how the circuit worked. Moreover, Mary and I were not able to move her from this stance, even though what counted for her as explanation counted for us only as description. My suggestion to separate learning to use SAM to animate from making animations about electronic circuits brought about the first qualitative reorganization of the PLA.

The "non-physics" session that followed was successful in teaching Daisy to use SAM's animation capabilities. It also taught her to enlist SAM to organize social interactions that met local (math tutoring) and personal (identity-work) goals. Now the test would be to see if Daisy could use what she'd learned about animation of math homework for the practical purpose of completing school work and apply it to making movies about circuits for explanatory purposes.

2.3 The Second Developmental Reorganization

In the telementoring session that followed the math animation session, Daisy was able to incorporate some animation into her SAM movies about circuits. The animations showed which of the 6 different circuits did and did not work but like her first video, these videos were devoid of any explanation about *why* each circuit did or did not work.

Daisy continued to maintain that in order to explain herself through her movies, she needed to use some kind of written means as part of the animation. This led us to suggest the use of “creative” procedures such as voice-overs, assuming that by their nature they would evoke explanatory talk. However, the problem of description remained. After making animations for each of the six circuits Daisy wrote detailed descriptions of what the viewer was seeing from one frame to the next, but did not include any discussion about what made the circuits functional. Daisy was replicating her descriptive approach to “explanation” in yet another way.

I was not immediately concerned by this turn of events. I was more worried about keeping Daisy involved in the PLA, which required that she experience success and enjoyment in participating. Consequently, I focused on ensuring that Daisy could work unselfconsciously on her movies — i.e. without “disrupting” adults looking over her shoulder. This is why I arranged to be in the room for Daisy’s next local video-production session, but I busied myself with other tasks so that Daisy could work on her own. Under these circumstances, Daisy cannily invented the voice-over co-authoring technique.

With this technique, Daisy provoked a second qualitative change in the PLA which rearrangement of the whole social organization of the activity, including the division of labor. Now Daisy was effectively co-producing her videos with younger girls.

While the voice-over co-authoring technique was clever, educational, and inclusive of others at the center, it still did not elicit from Daisy talk that explained how the circuits worked. However, given how the voice-over co-author technique re-engaged Daisy in the PLA, Mary and I did not consider it to be on the whole disruptive. Daisy was excited to bring in more girls to help with her movies. In the process she taught them how to build circuits, make animations, and record voice-overs. Clearly learning was happening.

2.4 The Third Developmental Reorganization

As a result of our acceptance of Daisy's voice-over co-authoring technique, the seed was planted for *the* disruption (the "Pedagogical Clash") that would create the conditions for the successful parallel circuit session. For the seed to sprout, however, other pre-conditions had to come together. Most consequential was the fact Mary, in Colorado, having given her approval to Daisy's movie-making approach in the first topic sequence on circuit building, decided not to supervise Daisy's video production activities in the second topic sequence on conductivity.

These circumstance generated a host of unanticipated consequences. When Aisha undermined Daisy's authority, she pushed Daisy to change her movie-making approach in order to save face. But Daisy's careless construction of her questions in the *multiple choice* video led me to intervene so that Daisy could actually save face, not just with Aisha but with our partners in Colorado. I didn't want Daisy to shame Aisha or herself. I wanted her to use her movie to occasion authentic, documentable scientific problem solving .

My reframing of the convoluted multiple choice question had the effect that I desired. Daisy ended up teaching Aisha how to build circuits that tested conductivity. In the process they had authentic conversations about the relationship between the material properties of the objects they tested and the functionality of the circuit. At the same time, they discussed their ideas about how electricity flowed in a circuit and they documented this discussion in SAM for Mary to see.

As we now know, behaviors that from my perspective looked like a resounding success were seen by Mary as a threat to the integrity of her curriculum and, by extension, to Daisy's learning. The planning session where this contrast — the Pedagogical Clash — came to the surface led directly to the major restructuring of the PLA. Not only did Mary withdraw from the activity, with Tom taking over, but the framing of the task changed from a logocentric to a pragmatic orientation (lighting a scale model house). From a research standpoint, the Pedagogical Clash was significant because it was a moment in which the distinction between the logocentric and pragmatic epistemes was made explicit.

3. Reevaluating the Logocentric, Pragmatic, and Mediational Strategies in Context

Armed with this history of the interplay of logocentric and pragmatic epistemes, I now return to the parallel circuit session to re-evaluate our understanding of the logocentric, the pragmatic, and mediational strategies that we first examined in Chapter Three. I perform this reevaluation as an entree into a re-examination of what was successful about the parallel circuit session and what was successful about the PLA as a whole.

As the history recounted in Chapter Four shows, the tension between logocentric and pragmatic orientations that can easily be observed in the parallel circuit session was present, though under-appreciated, from the start of the project. I devote this section and the one that follows to a re-examination of the parallel circuit session in the light of the evolution of the logocentric-pragmatic tension, and the strategies mediating the conflicts that resulted from these tensions. I begin, as did the project, by focusing on the logocentric episteme, and then shift my focus to the pragmatic episteme which dominated at the end.

3.1 Highlighting the Logocentric

I have argued that a key reason why Daisy was able to build the parallel circuit was because there had been a consequential shift in the telementoring session in the epistemic orientation of the collective participation framework. This shift began when Tom gave up trying to get Daisy to articulate in her own words the problem with the faulty circuit. At that moment Tom effectively yielded the session to me. I completed the shift by asking Daisy and Vicente to tell me how they could actually fix the circuit.

Recall that Tom, frustrated with Daisy's preference for trial and error experiments on the CCS, told her that "the idea here is not to kinda guess and check but to actually know why the thing works," (transcript, 8/18/09 telementoring session). Similarly, during the Pedagogical Clash, Mary argued that: "First you say what you think, then you say why you think it, and the reason why you do that is so that you have an understanding of what your current model is," (transcript, 5/27/09 planning session). With Mary's words as background, we now have a clearer sense of what exactly Tom was giving up when he turned the parallel circuit session over to me: logocentrism manifested in the ability to generalize, to rely solely on logical relations to solve problems regardless of the context. From this point of view, being able to create the circuits without the proper kind of explanation was not a success.

In light of this prior information we can better understand both the motivation behind, and the confusion produced by, Tom's instructional moves in the parallel circuit session. In his effort to get Daisy to articulate the problem with the faulty circuit, Tom effectively prevented her from doing the one thing that she thought she was supposed to do: fix the circuit. However, without the faulty circuit on the screen, there would have been no object present to refer to and theorize about. The presence of the faulty circuit for purposes of talking about it conflicted with Daisy's goal of fixing the circuit (particularly when she had already identified the wire that needed to be removed).

Looking back to the beginning of the PLA, we found that the sense of the logocentric as the ability to generalize was not explicitly discussed, but it was present beneath the surface. It was an initial unspoken, ***pre***-supposition of the researchers that Daisy would "naturally" use SAM as a tool for *explaining* circuit building principles. With each unexpected move Daisy made in her use of SAM, our sense of the logocentric-pragmatic tension became clearer. For example, Daisy's first text-only SAM video was, on its surface, a logocentric product. It included scientific terms, and was structured like a lab-report. However, it was obvious to us that Daisy was not thinking about the circuits in terms of the basic principles that explained how they worked. She was instead attempting to "pass" by applying routines learned in the classroom. It was clear that she was "performing *without* competence" and was not taking up the ideas, concepts and content defined by the curriculum (Kelly & Green, 1998). At this point in the project, simply using scientific terms and practices did not count as adequate.

Our understanding of the logocentric-pragmatic tension was further refined when Daisy went on to make circuit animations. By only describing which circuits worked and which did not, Daisy's new animated circuit videos further highlighted our error in assuming that Daisy would be inclined to think and talk about circuit functionality in an explanatory/logocentric manner. At the same time, it also became more obvious that we were mistaken in taking for granted that animation software was the right tool for this conceptual task of learning about circuits and conductivity.

The Pedagogical Clash was the point at which there was least ambiguity about the logocentric-pragmatic tension. In order to put an end to what Mary described as the “slowing” approach that Daisy was taking with her SAM movies, Mary was forced to be explicit about what it was that she expected from Daisy. It was at this moment in the project that the logocentric was spelled out, in Mary’s words as “having a model;” in other words as being able to *explain*.

We can now see that Tom and Mary shared this sense of the logocentric as explanatory. Not only did they both explicitly define their expectations of Daisy’s learning in similar ways (see above), they also sought to get Daisy to adopt this mode of thinking by having her stop and think before she acted. Tom tried to do this through his persistent questioning of Daisy. This questioning modeled scientific thinking, but it simultaneously prevented Daisy from following through on her own tendency to physically manipulate the CCS. It frustrated her to the point where she withdrew from active engagement. For her part, Mary enforced the “stop and think” approach when she requested that Daisy no longer involve other girls in the PLA. Mary concluded that Daisy was using the voice-over co-author technique as a way to avoid thinking ahead. There was validity to this interpretation: Daisy, after all, invented the technique as a substitute for writing voice-over scripts in advance.

3.2 Highlighting the Pragmatic

The restructuring of the PLA that followed the Pedagogical Clash marked a transformation in the relationship between goals and tools in the PLA. As it was originally designed, the PLA asked students to perform an expository (logocentric) task. SAM was *assigned* to the students for use in communicating what they had learned in the instructional phase of each topic sequence. The assumption was that through the process of trying to make visible for an audience what one had learned, students would understand the principles of circuit construction and be able to explain these principles. However, SAM was not fundamental to this process. Presumably, any media could have been used so long as the student could use it to communicate ideas about circuits.

With the house wiring project, solving a practical problem replaced exposition as the overarching goal. Given this goal, Daisy found the CCS a logical tool to use. It was helpful to her for figuring out the practical (pragmatic) problem of lighting the individual rooms in the scale model home. In other words, the CCS became a tool to build a parallel circuit.

Given the change in goals and tool use from the SAM-based activities to the house wiring project, both Tom's repeated insistence on "stop and think" (explanation) and Daisy's embodied and active use of the CCS now made sense. Daisy's disengagement from the activity when Tom prevented her from fixing the circuit also made sense. Tom would not abandon his logocentric stance, while Daisy would not (or could not) abandon her pragmatic stance. More importantly, Daisy's *re-engagement* with the activity after the shift in epistemic orientations that took place at the end of the parallel circuit session also made sense. This shift — from the logocentric, explanatory orientation that Tom was promoting, to the pragmatic, build-the-circuit orientation that I proposed — constituted a realignment of the collective participation framework with the functional, pragmatic goals that characterized the PLA following the major restructuring. The difference now, in the house wiring project (pragmatic) vs. the SAM-based activities (logocentric), was that Daisy herself saw the CCS as necessary for accomplishing the pragmatic goal of the activity. In other words, the tool could be lined up with Daisy's goals for the house lighting task.

Prior to the Pedagogical Clash, the framing of the relationship between goal and means was ambiguous. The instructions Daisy was given for using SAM included (from the distributed worksheets) to "make a documentary of what you learned" and from interactions with Mary and me, to make a video that would explain what had been learned to someone who was new to the material. This prescriptiveness is a good example of formal education: Daisy was being told how to use the focal tool to meet the prescribed goal of explaining the basics of electronic circuits. At the same time, and as we we discussed in the prior section, the SAM-based activity was also formal in that the unspoken expectation coming from Colorado and me was that Daisy should ultimately use SAM to engage in logocentric thinking and communication.

In light of the ambiguous instructions for using SAM, the descriptive videos that Daisy ended up making were perfectly legitimate behaviors within the PLA. Daisy was in fact representing what she had learned, it just wasn't what Mary and I were seeking. It was only after Daisy made her videos, that Mary and I were forced to re-think how we had instructed Daisy to use SAM, and to do this we needed to make explicit the kind of explanatory work we had anticipated Daisy would engage in.

Here we see another contrast between what pragmatic tool use meant before and after the Pedagogical Clash. In the SAM-based iteration of the curriculum, Daisy was prescribed a vague goal (show what you learned) to which she had to apply a prescribed tool (SAM). As noted, there was no obvious reason why SAM *had* to be used, but Daisy was quite nimble at finding reasons. She drew on the local, informal norms to make sense of the formal prescriptions emanating from Colorado. These norms legitimated her movie-making approach, an approach in which she had agency over how SAM was used, and which allowed her to satisfy her own and local expectations. The problem was that by doing this, Daisy was creating a context for SAM that made sense locally, but that deviated from the rules of instruction prescribed by Colorado.

The transformation of the PLA to the house wiring project represented a change in the epistemic orientation and structure of the activity, one in which the tools prescribed aligned with the prescribed goals. In hindsight we see that this was not the case at the beginning of the project: there was a disconnect between SAM and the goal to which it was to be applied.

3.4 Highlighting Mediational Strategies and Human Mediation

The historical transformations in how the pragmatic and logocentric epistemes were understood were accompanied by changes in the way that translation, backchanneling, and tool-use practices were deployed. These strategies were in a relationship of mutual transformation with the epistemes, as they mediated the conflicts stemming from the logocentric-pragmatic tensions. The enactment of *tool-use practices* articulated the epistemes. *Translation* mediated between the epistemes of the two settings and their representatives in the PLA, thereby constraining or enabling particular forms of tool-use and goal-formation. *Backchanneling* mediated participant resistance or acquiescence to the epistemes.

As we saw in Chapter Four, the interrelationship among the mediational strategies and the epistemes played out across all three categories of PLA sessions. For example, when Daisy made her text-only video (tool-use) in a local session, the planning session that followed allowed Mary and me to critically evaluate Daisy's actions (backchanneling) without fear of her walking away. The process of evaluation also involved translation: I provided Mary with context about Daisy's actions and Mary assessed the degree to which Daisy's actions conformed with logocentric expectations. After jointly concluding that Daisy needed to both animate and explain, Mary and I also strategized about how to engage Daisy in subsequent telementoring sessions. These decisions led to actions that transformed the ways that subsequent telementoring sessions were implemented, and these changes in turn led to changes in the way Daisy engaged in the activity (e.g. she went on to incorporate animations in her videos).

The dynamic among the mediational strategies and epistemes in the events leading up to the parallel circuit session brought about a transformation in the overall framing of the activity from a logocentric to a pragmatic orientation. As we saw in the parallel circuit session, this transformation in epistemic orientation at the inter-session level also occurred at the intra-session level. I am referring here to the epistemic shift in the parallel circuit session that took place when Tom ceased his questioning of Daisy (dropping the logocentric focus) and I reoriented the session back to the task of building the circuit (refocusing on the pragmatic).

In the parallel circuit session, and in the PLA overall, how and when I deployed mediational strategies was informed by more than two years of experience co-developing and co-supervising the Learning Lounge. As was evident in the analysis and history presented in Chapters Three and Four, whenever possible I tried to incorporate local norms into the PLA in ways that appealed to Daisy and abided by Colorado's educational expectations. For example, this is what I believed I was doing when, just prior to the epistemic shift in the parallel circuit session, I invited Vicente to join us. I was following a local practice meant to promote learning through interaction and collaboration, a practice that I had engaged in frequently in my years at the center. As it turned out, Vicente's presence contributed to the epistemic shift both by lightening the mood and by occasioning a division of the problem solving labor between him and Daisy[20] (Chapter Three, Example 4, Lines 88 −91, p.85).

Just as I "allowed" Vicente to join us, I also "allowed" the change in mood and action that Vicente's presence induced. At the time, Daisy and Vicente were working with me in a separate activity to run a kids summer camp at the Learning Lounge. The three of us were on friendly terms. This is obvious in the way that I joined in the backchanneling that lightened the mood. I was in effect condoning Vicente and Daisy's playfulness when,

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[20] In an informal interview after the PLA project was completed, Tom confirmed that he found the unexpected participation of other students in the PLA to be disruptive for his teaching (Tom Interview transcript, 8/25/11).

out of Tom's sight, I laughed and smiled along with Daisy and Vicente (Chapter Three, Example 4, Lines 101-104, p.86).

My personal relationship with Daisy, both in and out of the PLA, also informed how I interpreted Daisy's behavior in the parallel circuit session, and, therefore, it played a role in shifting the epistemic orientation. I knew Daisy well by the time the parallel circuit session took place. I had spent more than a hundred hours interacting with her in all manner of activities in the Learning Lounge. This was a history in which I got to know Daisy's personality, interests, her place and ambitions within the Learning Lounge's social hierarchy, and of course, her manner of dealing with the day-to-day demands of the PLA.

3.5 Reconsidering Success Through the Lens of Theory and Policy

Throughout this thesis I have grounded my analysis of the PLA in Daisy's successful construction of a parallel circuit using the CCS. With the critical information about the history of events that led up to this success in place, I turn now, as promised in Chapter One, to consider the implications for both theory and policy that this analysis has revealed.

3.5.1 Theoretical Considerations

A central aim of the foregoing discussion has been to demonstrate the usefulness of ideas and methods from Cultural-Historical Activity Theory (CHAT) and Distributed Cognition (DC) as productive conceptual tools for studying the complexities of designing and implementing physics telementoring activities through university-community afters-school collaborations. Both theoretical approaches provided me with the basic analytic categories for analyzing the dynamics of change across multiple timescales from the level of moment-to-moment interactions to sequences of coordinated events that continued over many months.

Every one of the major developmental reorganizations of the PLA described above could be readily analyzed in terms of participants' reorientations and realignments in interactional stances towards collective participation frameworks; each kind of PLA session (telemediated, local, and planning) could productively be characterized in terms of the participation frameworks they afforded. In the present case, examination of the parallel circuit session through the lenses of participation and stance helped us construct a framework for characterizing participants' logocentric and pragmatic orientations and for understanding the shifting deployment of the three key strategies that mediated these epistemic orientations.

3.5.1.1 "Daisy's Success"

In addition to providing tools for micro-analytic and retrospective analysis, these same theoretical approaches get us to adopt a critical stance toward our own theoretically motivated starting point—Daisy's success. Given our analyses, it is clear to us now, in a way that was unselfconsciously ignored in the course of the event itself, that if we are going to speak of Daisy's success, we need to acknowledge that this is a mere shorthand. Both DC and CHAT urge on us the realization that in order for Daisy to have built the parallel circuit, teaching-learning resources — the social, material, and content resources understood as necessary for creating opportunities to learn (Pullin & Haetrel, 2008) — had to be organized through processes that unfolded at multiple time scales (Lemke, 2000) and that were enacted by multiple people, using multiple tools, in multiple settings. Furthermore, whatever the success represented, it did not represent evidence that Daisy had demonstrated her knowledge of physics in a manner acceptable to cannons of physics and physics explanation. She built the circuit with a simulator, and in the process demonstrated that she understood enough of the principles involved to generalize her solution from two-bulb parallel circuit to a four- bulb circuit, but she never explained the principles underpinning her successful actions.

Even the use of the term "her successful actions" needs to be reexamined in light of the analysis in Chapter Three of the dynamics of communication in the parallel circuit session. In the end, Tom had little choice in reorienting his stance toward the task and participate in doing rather than explaining. Vicente's appearance, although unplanned, contributed to the change in the collective participation framework and with it the interpersonal relations that induced Daisy to stick with the activity, even as she was being confused by Tom's repeated questions about a problem she thought she had completed to everyone's satisfaction. Additionally, we also need to take into account the "actions" of the culturally constituted environment that enabled Vicente to be there. In the informal idioculture of the Learning Lounge, peeking your head into a room and asking to join an activity was not only acceptable, it was encouraged.

3.5.1.2 The PLA as Hybrid Activity

The cultural history of the parallel circuit session presented in Chapter Four reveals the logocentric and pragmatic epistemes as distinct expressions of the idiocultures manifested in the ongoing activity of the Colorado and Learning Lounge activity systems, respectively. This understanding of the epistemes is in line with the characterization of the PLA, proposed at the beginning of the dissertation, as an activity system that was an idiocultural hybrid of the Colorado and Learning Lounge systems (Figures 5.1 and 5.2). A comparison of Figures 5.1 and 5.2 contrasts the PLA activity structure before the PLA was restructured to incorporate the House Wiring Project, and after the epistemic shift in the parallel circuit session. The differences are depicted in terms of how the logocentric-pragmatic tensions were manifested in the relations that mediated collective activity in the system (community, rules, division of labor, tools, and objects).

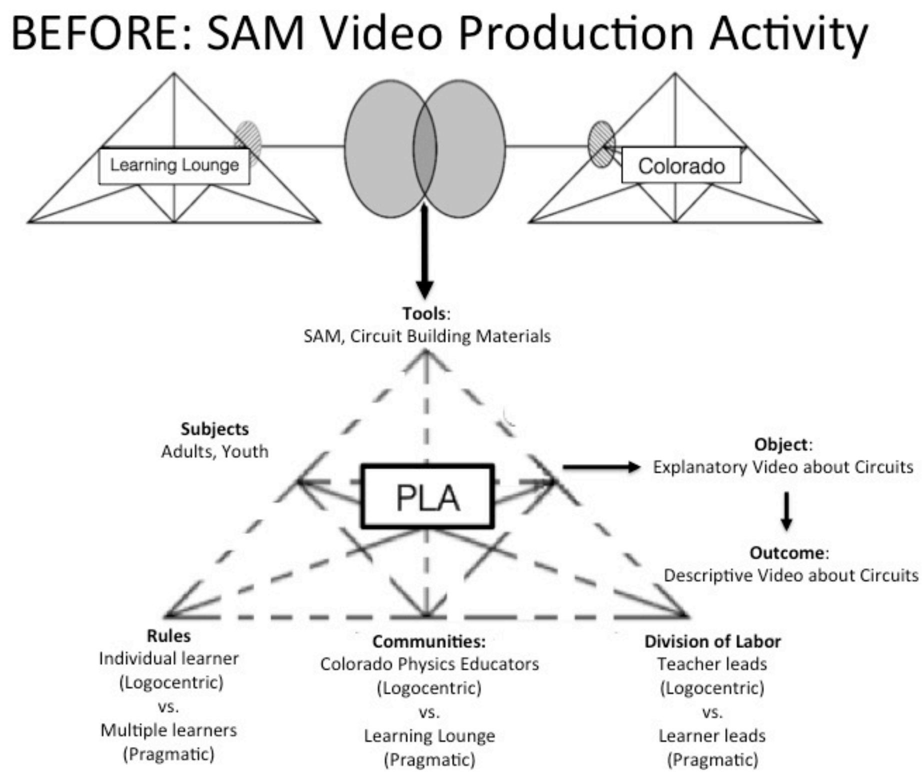

Figure 5.1: The PLA as an idiocultural hybrid of the Colorado and Learning Lounge activity systems using SAM videos to explain how simple circuits work. The PLA activity system triangle shows examples of the logocentric-pragmatic tension manifested in the mediational relationships that constituted the PLA activity system.

As shown in the figure, both the tool to be used and the object of activity were prescribed by the initially agreed upon curriculum. They were taken for granted and presumably unproblematic. However, as matters quickly emerged during this part of period of he PLA, the logocentric and pragmatic epistemes were manifestly in conflict with each other in terms of the rules, communities, and division of labor. As a consequences, the outcome of the activity was the unexpected production of a purely descriptive video.

Figure 5.2 depicts the changes in the constitution of the PLA at the time that the celebration of Daisy's success occurred.

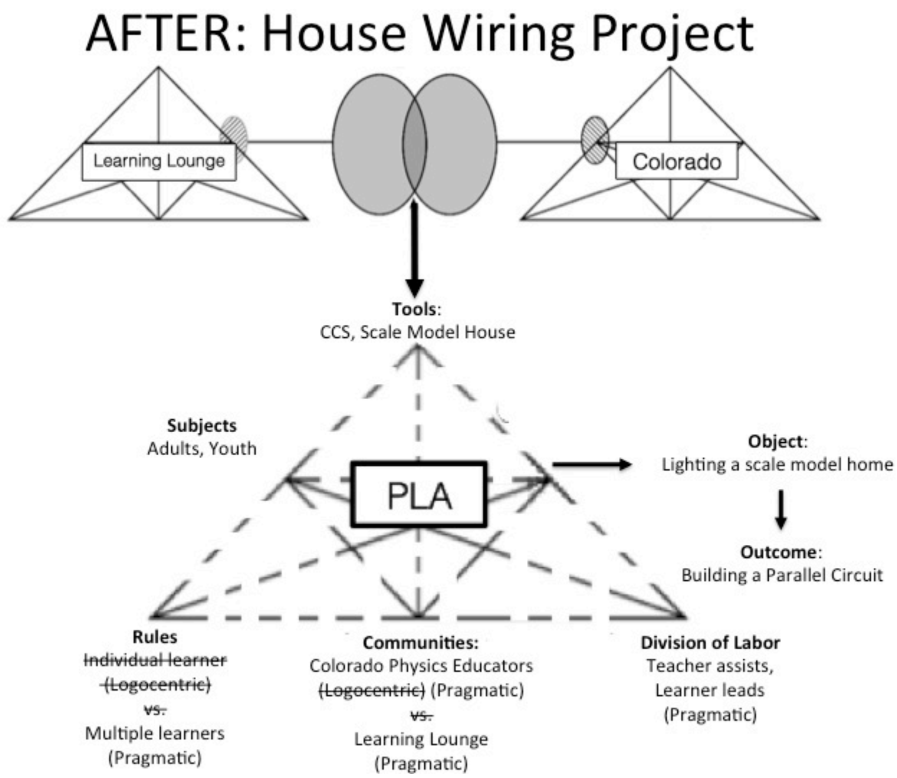

Figure 5.2: Organization of the PLA hybrid following the Pedagogical Clash. Adoption of house wiring as the object of the activity is accompanied by the resolution, for the time being, of the logocentric-pragmatic tension across crucial constituents of the activity. These changes are manifested in the mediational relationships that constituted the PLA activity system.

The relevant changes between Figure 5.1 and 5.2 can be enumerated for each of the nodes of the triangular representation.

1. The focal tool has changed. In place of the SAM software, there are two tools: The CCS and a scale model house with physical lights and batteries.
2. The subjects have changed. Mary has been replaced by Tom, and Vicente has joined Daisy.
3. The rules have changed. Now multiple learners are involved and they are allowed to help each other.
4. The community remains the same, a combination of Colorado and Learning lounge participants, but the Colorado participant has acceded to the practical task of figuring out how to get four rooms of a model house to light up "independently."
5. The division of labor has changed: The Colorado instructor (Tom), has given up on inducing Daisy to explain why the circuit on the CCS is problematic. This shift allows her to get on with her attempts to get the circuit to work. The learner leads the activity, the instructor and mediator assist in the learners' mode of action.
6. The object of activity has changed: The object how is to find a way to get four rooms of the scale model house to light up "independently."

These changes result in a paradoxical outcome. Although the presumed object of activity is to light up the rooms of the house, the celebration of success is not the result of Daisy getting the circuitry for the house to operate properly. Rather, that practical objective appears to operate as a "strategic fiction" (Newman, Griffin, & Cole, 1989) that allows Daisy to use the CCS as a genuine tool for creating parallel circuits. Under these mixed conditions, where the logocentric tool actually serves the pragmatic goal, Daisy uses the CCS in an effective fashion.

At this point, it is clear that there are many (somewhat differing) reasons for the members of the PAL to celebrate. Tom can celebrate the successful creation of a parallel circuit using the tool that served his initial logocentric instructional goals. Daisy can celebrate because now, for her, the CCS is a functioning representation of what she needs to do to light up the rooms of her house "independently." And I can celebrate because Daisy, clearly in command of the keyboard is making correct extrapolations from a single to a double, to four parallel circuits operating simultaneously and recognizes for herself that she has succeeded in what she set out to do.

3.5.1.3 Overgeneralizing the Efficacy the Tool

Given all the expertise the research collaborative had, including the expertise motivating the change of the PLA into the house wiring project, why didn't the PLA work out as we had anticipated when we first started the project? Here again a cultural archeology of the project is helpful.

Recall that the decision to implement the PLA was motivated by our prior success implementing a similar but smaller scale physics telementoring activity in the Learning Lounge. This was the project in which a fifth grader, Karl, learned to use SAM to explain constant speed and acceleration using SAM (p.34). Specifically, he was shown how to make animations that depicted different rates of motion by changing the position a plastic human figure along a segmented line from one frame to the next (e.g. constant speed was represented when the figure moved an equal distance between frames, acceleration when the figure moved at increasingly larger intervals between frames).

The difference in the way that SAM was used to teach motion compared to the way that it was incorporated in the PLA is striking. In the motion activity, there was a direct mapping between the content taught and the tool: the kind of motion depicted depended on how Karl used SAM to animate. Furthermore, Karl was specifically taught how to use SAM in order to depict the different kinds of motion.

In the PLA, there was no direct mapping between content and tool. Daisy was first taught a lesson on electronic circuits, *then* was asked to use SAM to make a video, “a documentary,” to explain what she had learned to someone who was naive about electronic circuits. In other words, using SAM to animate played no fundamental role in Daisy’s learning about circuits.

We see now that Mary, who was responsible for developing the curriculum for the PLA, overgeneralized how useful SAM would be as a general purpose device for teaching and learning about electronic circuits. However, the problem may not have necessarily been with her perspective on the usefulness of SAM, but with her assumptions about the ease with which students learn about electronics. In the planning meeting we held before starting the PLA sessions for the first time (10/10/08), Mary described electronics as “fundamental to everything in [a person’s] world” and as “totally easy to understand.” She also argued that “if fourth graders can be taught [electronics] it can also be taught to a 15 year old” (referring to Daisy). Additionally, as came to light in the Pedagogical Clash, Mary was confident in the curriculum she had developed for the PLA based on its proven success in classroom settings (Otero & Gray, 2008). We have no record of how Mary adapted the curriculum to fit with how she imagined the PLA would be implemented in the Learning Lounge with instruction coming through the internet from Colorado.

Our failure to see the disconnect between the tool and the content, and, more broadly, between the tool and goals, naturally leads to a discussion of policy: What can we do in the future in order to minimize the kinds of pedagogical and epistemic clashes evident in hybrid informal learning activities like PLA? This is an important question because such activities hold real promise for opening up new avenues of exploratory and authentically engaged learning, but it is a fragile promise, one that can be easily stamped out through too rigid an attitude about what counts as, and what tools are appropriate for, "legitimate" learning.

3.5.2 Policy Considerations

At the time that we implemented the PLA it embodied key principles that policy-makers believed were necessary for providing students with quality opportunities to learn STEM:

- It leveraged the latest information technologies to provide students with vetted content, as well as the latest in educational software and new media tools for engaging with this content in multiple modalities.

- It also gave students direct access to STEM experts to help them learn and interpret the content.
- Critically, the PLA was implemented in an out-of-school setting, an environment presumed to afford the flexibility required to incorporate self-directed, project-oriented activities recommended by STEM researchers and practitioners (National Research Council, 2009).
- Lastly, the PLA did all of this through an innovative organizational arrangement: a university-community after-school collaboration.

Given all of these claims, based on the data presented here, it would seem that the PLA should have been a highly successful endeavor. However, as the analysis and history presented in this dissertation have demonstrated, implementing a successful after-school STEM telementoring program is significantly more complicated than digitizing and delivering STEM instruction through a fiber-optic cable. Certainly technical changes to a next iteration of the project could be made to improve participant experiences of the activity (e.g. split screen video chat). However, no technological solutions currently in view will change the fact that -- as Daisy, Aisha, and the Learning Lounge taught us – material, conceptual, and social resources designed by educators and imported into community settings will be transformed in unexpected and sometimes unwanted ways as they are mediated by learners through local cultural practices, norms, goals, and tools. Put in common sense terms, the delivery of educational resources is not a turn key process -- it takes people to create, coordinate, and implement teaching-learning resources in ways that effectively accomplish teaching and learning across the formal and informal activity settings.

Considering the failure of the PLA to deliver on the aspirations of policy-makers and researchers, what might be said in its defense that resonates with the logocentric world of formal science education? Here we need to include all of the unanticipated learning that was mediated by the local informal, idioculture:

- Digital video production skills equivalent to those possessed by sophomores in communication at my university.
- Engagement in the use of stop motion animation software and a high level simulator for teaching about circuits.
- Engagement in inter-generational teaching and collaboration around academic subject matter involved in homework where they inhabited the teacher role.
- Extended experience in explaining how things work, even though the form of this experience, thinking-in-action did not count as relevant within the formal sector.

In light of the real complexities unearthed in this thesis, a central implication of this research — one from which other policy and educational design implications emanate — is that attempts to extend formal STEM education into everyday contexts will come into conflict with the freedom to choose means and goals that is characteristic of these settings. Researchers and practitioners on both sides of the university/ logocentric-community/pragmatic “divide” will need to carefully and collaboratively think about to the socio-cultural organization of the instructional activity to create workable hybrids, not just programs for providing academic enrichment through “giving” educational materials to after-school institutions. Such efforts failed before the invention of the internet, and they will fail now unless scholars and policy makers take the issue of bridging the formal and the informal in a common after-school activity seriously. The challenge is to find productive ways of resolving this basic contradiction in all such forms of activity.

In my view one goal for after-school education using the internet and social arrangements such as the university-community transaction is that it can allow connecting the everyday experience of the learners with more formal science learning. We want learners to be able to engage both logocentrically and pragmatically, to be able to “do” science and be able to explain it to themselves and to others. It is difficult to know how best to link those fleeting moments of informal exploration to the longer term objectives of deeper scientific education. That is a dissertation for another day.

APPENDIX

Appendix A: Transcript Conventions[21]

Convention	Name	Use
[text]	Brackets	Indicates start & end points of overlapping speech.
(# seconds)	Timed Pause	Time in seconds of a pause in speech
(.)	Micropause	Brief pause, less than 0.2 seconds.
?	Question mark	Indicates rising pitch or intonation
-	Hyphen	Abrupt stop or interruption in utterance
°	Degree Symbol	Quiet speech or whisper
ALLCAPS	Capitalized text	Indicates increased volume of speech
:::	Colons	Prolongation of sound
(@@@)	Arobase	Indicates laughter
(text)	Parentheses	speech which is unclear or in doubt in transcript
((text))	Italicized double parentheses	Annotation of non-verbal activity

Appendix B: Curricular Worksheets

In this section I include the worksheets from the curriculum that were completed in the PLA, sequences 1 and 2, "exploring battery-wire-light bulb circuits" (fall, 2008) and "Conductivity" (winter and spring, 2009). The reader will note that throughout this set of worksheets there are references to a "group" or to "working with your group." This is because Mary developed these worksheets for use in the physics outreach activities in after-school centers where she and university physics students under her supervision worked.

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[21] Sacks, Schegloff & Jefferson (1979).

Activity 1: Light the Bulb

Instructor Instructions:

1. Each student should have a lab book with a sticker on the front with their name, date, and location. Students should already have seen the Electric Circuit Demos and learned how to make a documentary.

2. These are the **materials** you will need for this activity:

2 Loose batteries	Loose bulb	3 alligator leads	2 bare copper wires
2 batteries in holder	Bulb holder	Switch	Computer
Camera	White board	Markers	Eraser
Camera holder	Scissors	Tape	

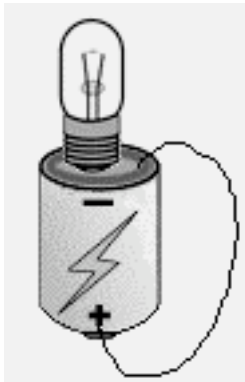
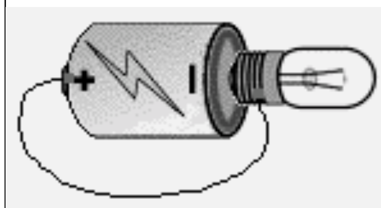
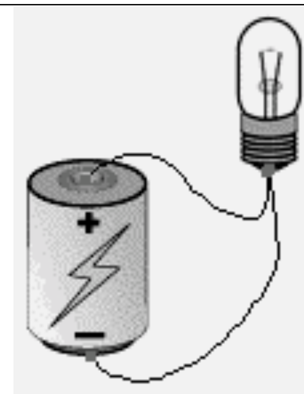
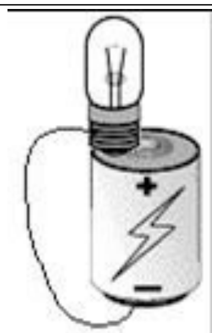
3. Cut out each sub activity and put into a folder. Give out one sub activity at a time. Do not give out the review sub activities on the same day that they do other parts of the activity; wait until the next day. Cut out extra documentary pages and cut outs below.

4. Make sure the student has completed the whole activity before initialing it. This is to make sure they do all of it. For predictions, the answers do not have to be correct, whereas for measurements or questions they may need to be. Use your judgment.

Activity 1.1 **Do this activity individually, not with your group. Instr. Init.______**

Imagine that you had a battery, a small bulb and some wires. You were curious about what arrangements would cause the bulb to light. Next are pictures of six possible arrangements, with brief descriptions of how the wires are connected in each case. Look at each arrangement carefully and **predict** whether that particular arrangement would cause the bulb to light.


Write “YES” next to Prediction: for each arrangement that you think would light the bulb. Write “NO” next to Prediction: for each arrangement that you think would not light the bulb.

 #1 **The tip of the bulb touches the negative end of the battery. A wire touches the negative end of the battery and the positive end of the battery.** **Prediction:____________**	 **#2** **The tip of the bulb touches the negative end of the battery. A wire touches the positive end of the battery and the metal side of the bulb.** **Prediction:____________**	 #3 **One wire touches the positive end of the battery and the tip of the bulb. A second wire touches the negative end of the battery and the tip of the bulb.** **Prediction:____________**
 #4 **The tip of the bulb touches the positive end of the battery (but not the knob in the middle). A wire touches the metal side of the bulb and the negative end of the battery.** **Prediction:____________**	**#5** **A single wire touches the positive end of the battery and the negative end of the battery. The tip of the bulb touches the middle of this wire.** **Prediction:____________**	 #6 **The metal side of the bulb touches the positive end of the battery. A wire touches the tip of the bulb and the negative end of the battery.** **Prediction:____________**

Activity 1.2 Do this activity individually, not with your group. Instr. Init.______

? What criteria were you using in making your decisions? That is, what did you think was necessary for the bulb to light?

<u>Activity 1.3</u> <u>Do this activity with your group</u> Instr. Init.______

Group members:____

Discuss your answers and reasons with your group members. If you change your mind, do not erase your original answer, but instead just add the opposite answer alongside your original answer.

<u>Activity 1.4 Do this activity individually, not with your group</u>. Instr. Init.______

Collecting and Interpreting Evidence

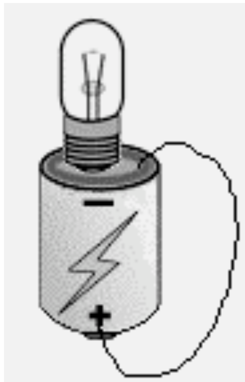
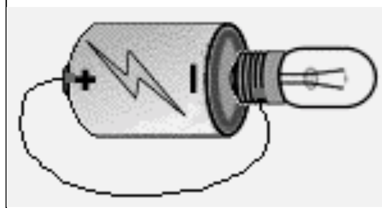
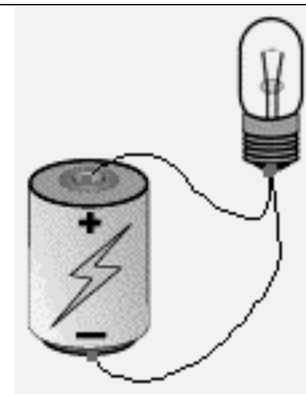
Experiment #1.4: What conditions are necessary to light the bulb?

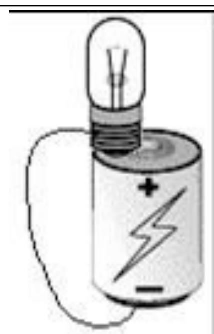
Each student will need:

- One loose battery, one loose bulb, two bare copper wires

Try each of the six arrangements pictured on the previous pages. In some cases you will need another group member to assist you to hold all the pieces together.

Write "YES" next to "Observation:" for each arrangement that actually lights the bulb, and write "NO" next to "Observation:" for each arrangement that does not light the bulb.

 **#1** **The tip of the bulb touches the negative end of the battery. A wire touches the negative end of the battery and the positive end of the battery.** **Observation:___________**	 **#2** **The tip of the bulb touches the negative end of the battery. A wire touches the positive end of the battery and the metal side of the bulb.** **Observation:___________**	 **#3** **One wire touches the positive end of the battery and the tip of the bulb. A second wire touches the negative end of the battery and the tip of the bulb.** **Observation:___________**

 **#4** **The tip of the bulb touches the positive end of the battery (but not the knob in the middle). A wire touches the metal side of the bulb and the negative end of the battery.** **Observation:___________**	**#5** **A single wire touches the positive end of the battery and the negative end of the battery. The tip of the bulb touches the middle of this wire.** **Observation:___________**	 **#6** **The metal side of the bulb touches the positive end of the battery. A wire touches the tip of the bulb and the negative end of the battery.** **Observation:___________**

<u>Activity 1.5 Do this activity individually, not with your group</u>. Instr. Init.______

Which of the setups use a battery, bulb and a single wire and the bulb lights?

Activity 1.6 Do this activity individually, not with your group. Instr. Init.______

Figure out one more different arrangement of battery, bulb and a single wire that lights the bulb.

Draw a sketch of your new successful arrangement.

Activity 1.7 Do this activity individually, not with your group. Instr. Init.______

Figure out an arrangement using the battery, bulb and two wires that light the bulb.

Draw the circuit below.

Activity 1.8 Do this activity individually, not with your group. Instr. Init.______

Storyboard a documentary about what you learned in Activities 1.1 to 1.7. Include all the sub activities. After we make a SAM movie, remember that we will be showing this movie to everyone, so make sure it is complete!

Documentary Checklist:

1. Title, names of all group members
2. General Idea slide
3. “The End!”
4. Complete?

Title: Names: 1	General Idea: 2
3	4
5	6
7	The End 8

<u>Activity 1.9 Do this activity with your group</u>. Instr. Init.______

Group members:____

SAM

Make a stop action motion (SAM) movie Documentary using your storyboard ideas from Activity 1.8. Include all the sub activities. Remember that we will be showing this movie to everyone, so make sure it is complete.

<u>Activity 1.10 Do this activity individually, not with your group</u>. Instr. Init.______

In which of the 6 original setups does a wire directly go from the positive to the negative end of the battery without touching the two parts of the bulb?

Did the bulb light in any of those cases?

In those cases did you notice if the wire got warm?

Did the thickness of the wire make a difference? Explain.

<u>Activity 1.11 Do this activity individually, not with your group</u>. Instr. Init.______

Look over all the arrangements that allow the bulb to light, and answer the following questions.

Which part or parts of the **battery** need to be part of the connections?

Does a wire or part of a bulb need to touch the positive end of the battery only where the knob is, or can it touch any place on the positive end of the battery away from the knob?

Which part or parts of the **bulb** must be touched to make the bulb light?

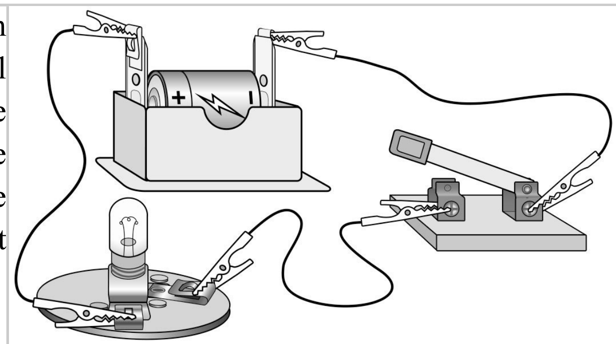
Activity 1.12 Do this activity individually, not with your group. Instr. Init.______

It is awkward to hold the battery, wires and bulb together to build circuits. To make things easier, there are special holders for the battery and for the bulbs, and special hook-up wires that have ends that are easy to attach. There is also a switch to make it easier to open and close the circuit.

Each student will need:

- Switch, bulb holder, battery holder and three hook-up wires

Get a battery holder, bulb holder, switch and three hook-up wires with small alligator clips on their ends. Snap the battery into its holder, and screw the bulb into the bulb holder. Use the three hook-up wires and connect the circuit together with the switch.

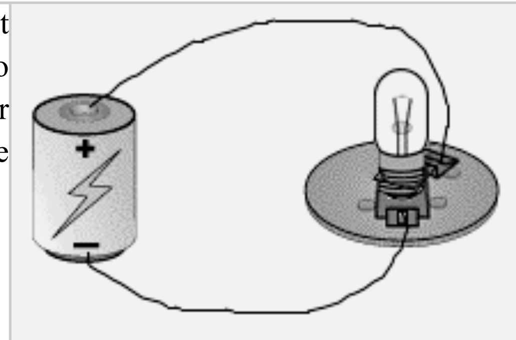


With the handle of the switch down between the clip, the bulb should light. The circuit is said to be "closed." When the handle is lifted up, the bulb should stop glowing, and the circuit is "open."

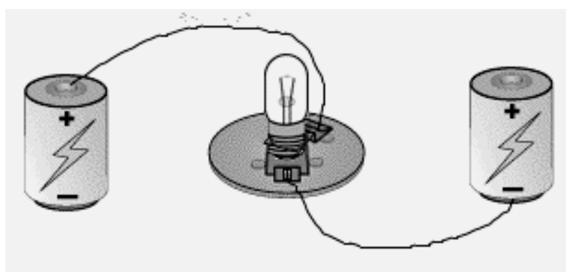
<u>Activity 1.13 Do this activity individually, not with your group</u>. Instr. Init.______

Experiment #1.13: How do the two ends of the battery need to be connected to the two sides of the bulb?

The evidence from Activity 1.4 suggests that one side of the bulb needs to be connected to the positive end of the battery, and the other side of the bulb needs to be connected to the negative end of the battery.



But do the two sides of the bulb need to be connected to the positive and negative ends of the **same** battery? Consider the following arrangement:



Do you think the bulb in the above arrangement will light? Explain your reasons.

<u>Activity 1.14 Do this activity individually, not with your group</u>. Instr. Init.______

Get two batteries, two hook-up wires and a bulb in a socket. Hook up the arrangement shown above.

Does the bulb glow?

Do the two ends of the bulb need to be connected to the two ends of the **same** battery for the circuit to work?

 How do you know?

Activity 1.15 Do this activity individually, not with your group. Instr. Init.______

 Storyboard a documentary about what you learned in Activities 1.10 to 1.14. Include all the sub activities. After we make a SAM movie, remember that we will be showing this movie to everyone, so make sure it is complete!

Documentary Checklist:

1. Title, names of all group members
2. General Idea slide
3. "The End!"
4. Complete?

Activity 2: Conducting Materials

Instructor Instructions:

1. Each student should have a lab book with a sticker on the front with their name, date, and location. Students should already have seen the Electric Circuit Demos and learned how to make a documentary.

2. These are the **materials** you will need for this activity:

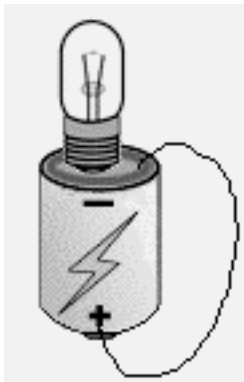
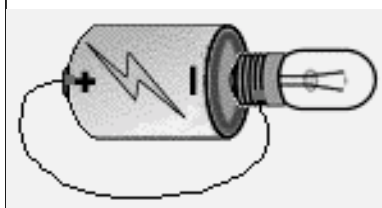
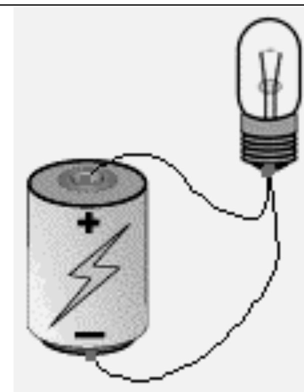
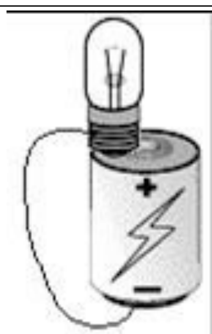
2 Loose batteries	Loose bulb	3 alligator leads	2 bare copper wires
2 batteries in holder	Bulb in holder	Switch	Computer
Camera	White board	Markers	Eraser
Camera holder	Scissors	Tape	

3. Cut out each sub activity and put into a folder. Give out one sub activity at a time. Do not give out the review sub activities on the same day that they do other parts of the activity; wait until the next day. Cut out extra documentary pages and cut outs below.

4. Make sure the student has completed the whole activity before initialing it. This is to make sure they do all of it. For predictions, the answers do not have to be correct, whereas for measurements or questions they may need to be. Use your judgment.

<u>Activity 2.1</u> **<u>Do this activity individually, not with your group</u>. Instr. Init.______**

Below are the circuits from Activity 1.

 **#1** **The tip of the bulb touches the negative end of the battery. A wire touches the negative end of the battery and the positive end of the battery.**	 **#2** **The tip of the bulb touches the negative end of the battery. A wire touches the positive end of the battery and the metal side of the bulb.**	 **#3** **One wire touches the positive end of the battery and the tip of the bulb. A second wire touches the negative end of the battery and the tip of the bulb.**
 **#4** **The tip of the bulb touches the positive end of the battery (but not the knob in the middle). A wire touches the metal side of the bulb and the negative end of the battery.**	**#5** **A single wire touches the positive end of the battery and the negative end of the battery. The tip of the bulb touches the middle of this wire.**	 **#6** **The metal side of the bulb touches the positive end of the battery. A wire touches the tip of the bulb and the negative end of the battery.**

Activity 2.1 part 2

In which of these circuits does a wire directly go from the positive to the negative end of the battery without touching the two parts of the bulb?

Did the bulb light in any of those cases? (Test it if you are not sure!)

In those cases did you notice if the wire got warm? (Test it if you are not sure!)

Did the thickness of the wire make a difference? Explain.

Activity 2.2 Do this activity individually, not with your group. Instr. Init.______

Look over all the arrangements that allow the bulb to light, and answer the following questions. (Test which ones light if you are not sure!)

Which part or parts of the **battery** need to be part of the connections?

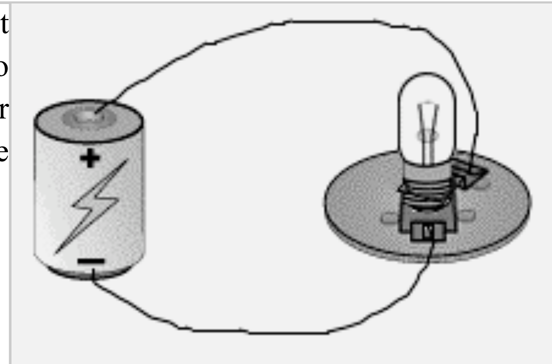
Does a wire or part of a bulb need to touch the positive end of the battery only where the knob is, or can it touch any place on the positive end of the battery away from the knob?

Which part or parts of the **bulb** must be touched to make the bulb light?

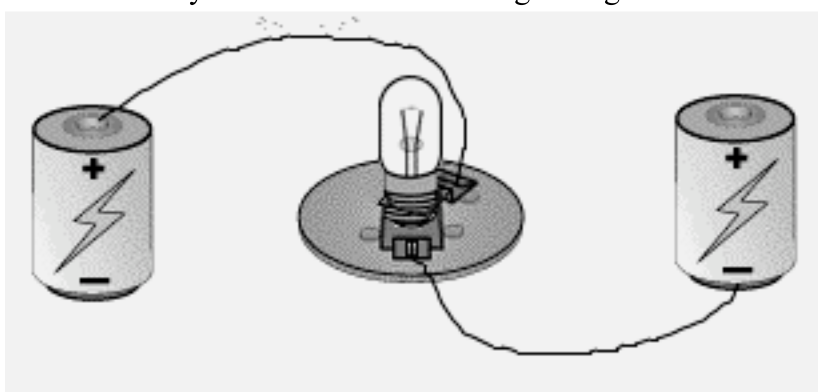
Activity 2.3 Do this activity individually, not with your group. Instr. Init.______

Experiment #2.1: How do the two ends of the battery need to be connected to the two sides of the bulb?

The evidence from Activity 1.4 suggests that one side of the bulb needs to be connected to the positive end of the battery, and the other side of the bulb needs to be connected to the negative end of the battery.



But do the two sides of the bulb need to be connected to the positive and negative ends of the **same** battery? Consider the following arrangement:



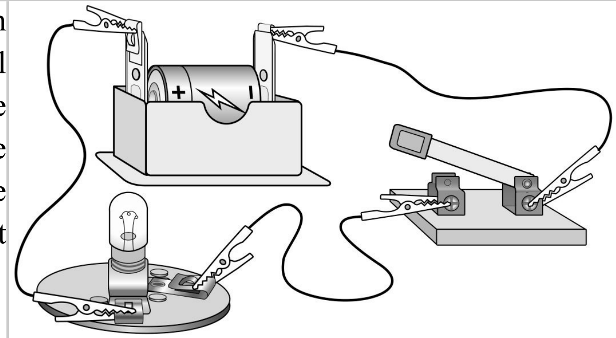
? Do you think the bulb in the above arrangement will light? Explain your reasons <u>without testing</u> it yet!

<u>Activity 2.4 Do this activity individually, not with your group</u>. Instr. Init.______

It is awkward to hold the battery, wires and bulb together to build circuits. To make things easier, there are special holders for the battery and for the bulbs, and special hook-up wires that have ends that are easy to attach. There is also a switch to make it easier to open and close the circuit.

Each student will need:

- Switch, bulb holder, battery holder and three hook-up wires

Get a battery holder, bulb holder, switch and three hook-up wires with small alligator clips on their ends. Snap the battery into its holder, and screw the bulb into the bulb holder. Use the three hook-up wires and connect the circuit together with the switch.	

With the handle of the switch down between the clip, the bulb should light. The circuit is said to be "closed." When the handle is lifted up, the bulb should stop glowing, and the circuit is "open."

<u>Activity 2.5 Do this activity individually, not with your group</u>. Instr. Init.______

Get two batteries, two hook-up wires and a bulb in a socket. Hook up the arrangement in Activity 2.3.

Does the bulb glow?

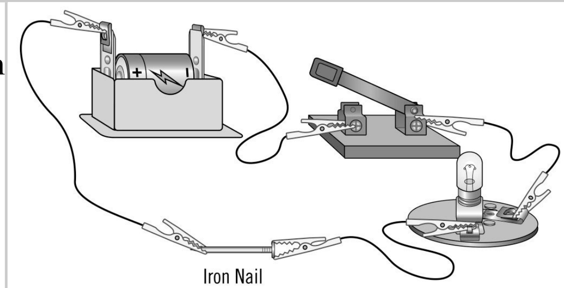
Do the two ends of the bulb need to be connected to the two ends of the **same** battery for the circuit to work?

How do you know?

Activity 2.6 **Do this activity individually, not with your group. Instr. Init.______**

Experiment #2.1 In the previous experiment you used copper wires to connect the battery and bulb together. (At first you just used bare copper wires. Then, to make it easier to connect things, you used special copper wires with a surrounding plastic sheath and metallic alligator clips at its ends.) Does it make a difference what kinds of materials you use to connect the battery with the bulb? Will anything work to allow the bulb to light? You will try to answer those questions in this experiment.

In the circuit drawing, notice that an iron nail is in the path of the circuit.



For each object in the following table, say if you think the bulb will light.

Table 2.1 Prediction of materials that allow the bulb to light

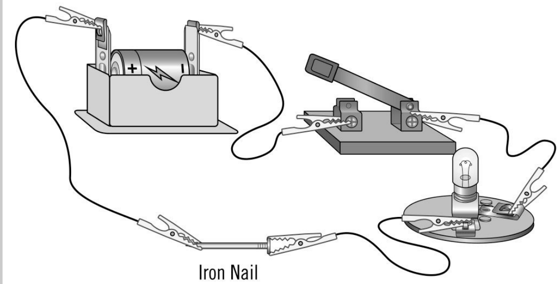
Item and material	**Does the bulb light? (YES or NO)**
iron nail	
wood stick	
glass rod	
aluminum foil	
copper wire	
steel nut	

Activity 2.7 **Do this activity with your group. Instr. Init.______**
Group members:____

Your group will need:

- Battery in battery holder, bulb in bulb holder, switch, 4 hook-up wires,
- Various items made of different materials, like an iron nail, wood stick, glass rod, aluminum foil, copper wire, steel nut, etc.

Construct a circuit similar to the one shown in the picture. The iron nail is placed in the circuit. At the start the switch handle is up. Close the switch.



- • Does the bulb light? Record your observation i

- n the Table.

Repeat for all of the other items that you gathered.

Table 2.2: Materials that allow the bulb to light

Item and material	Does the bulb light? (YES or NO)
iron nail	
wood stick	
glass rod	
aluminum foil	
copper wire	
steel nut	

<u>Activity 2.8</u> <u>Do this activity with your group</u>. Instr. Init.______

Group members:____

Try two or three additional items to see whether they will allow the bulb to light.

Add your observations to the Table.

What seems to be common about the types of materials that need to be included in the loop of an electric circuit so the bulb will light?

Activity 2.9 Do this activity with your group. Instr. Init.______

Information: Materials that can be included in a circuit to light the bulb are called **conductors**. Materials that do not allow the bulb to light when included in a circuit are called **insulators**.

Activity 2.10 Do this activity individually, not with your group. Instr. Init.______

Storyboard a documentary about what you learned:

1. In Activity 2.1, draw one circuit in which the wire got warm. Why?
2. In Activity 2.3, did the bulb light up? Why or why not?
3. In Activity 2.7, (Table 2.2), show three things that made the bulb light and three things that did not. For the things that made the bulb light, what did they have in common?
4. Add one more thing you learned from this activity…be creative!

After we make a SAM movie, remember that we will be showing this movie to everyone, so make sure it is complete!
Documentary Checklist:

1. Title, names of all group members
2. General Idea slide
3. "The End!"
4. Complete?

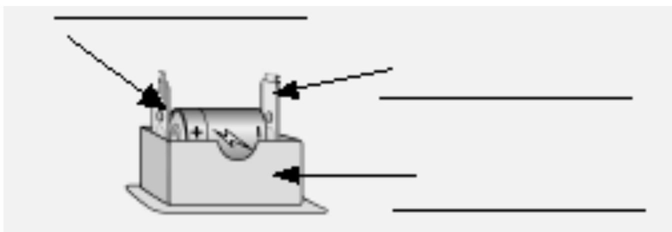
Title: Names: 1	General Idea: 2
3	4
5	6
7	8

Review Question

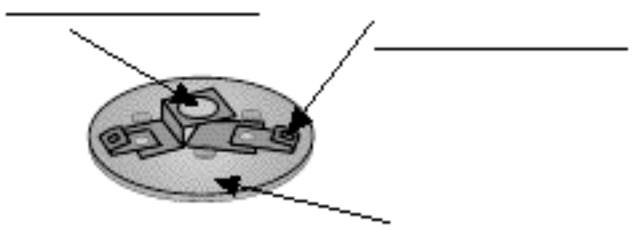
<u>Activity 2.R1</u> <u>Do this activity individually, *not* with your group</u>. Instr. Init.______

Below are pictures of a battery holder, bulb holder and switch. Several parts of these components are identified. Indicate whether you think each part is a **conductor** or an **insulator**. <u>Justify your answers</u>.

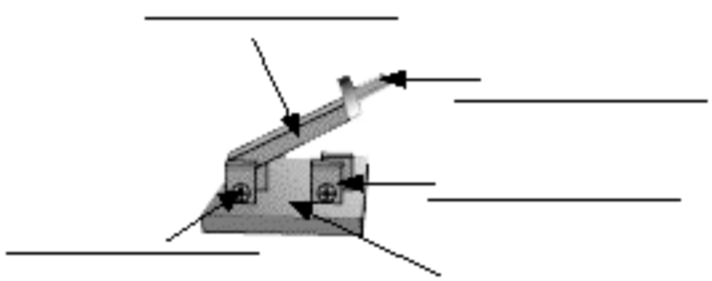
(a)

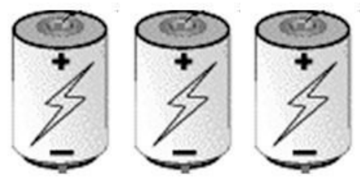


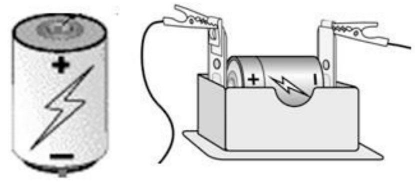
(b)

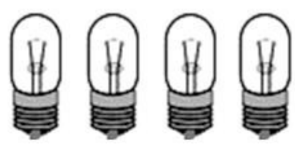


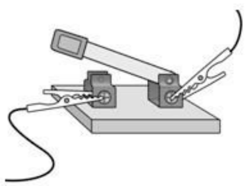
(c)











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