When the Classroom Isn't in School:

The Construction of Scientific Knowledge in an After-School Setting

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[do not quote]

> "The [National] Commission [on Mathematics and Science Teaching for the 21st Century] is convinced that the future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically" (NCMST, 2000, p.4)

Recent calls for improving school aged children's achievement in science have stirred debate and public discussion at every level of the educational process. These discussions have been prompted by the recognition of our nation's failure to adequately prepare students. Whether measured in the international (NCES, 1995) or national (NCES, 2000) arenas, our children are not mastering mathematics or science sufficiently. According to the NAEP study (NCES, 2000) less than one third of students achieve a "proficient" level of science achievement—that is, only a fraction of the students tested demonstrated competency over challenging subject matter. At twelfth grade, almost half the students do not attain "basic" levels of achievement, meaning that they lack "partial mastery of the knowledge and skills that are fundamental for proficient work at a given grade"(NCES, 2002, p. 1). As a result, a broad range of calls for improving student achievement has been issued (e.g., NCMST, 2000 or Department of Education, 2002).

In many ways, these calls echo the national emphasis on science education that was present in the 1940's to 1960's (Lopez & Schultz, 2001). In the aftermath of World War II it was recognized at the national level that science was critical in the advancement of society (Bush, 1945). The Cold War and Space Race of the 1950's and 1960's added urgency to the development science and a new generation of scientists. In the early 60's our need (however distant – literally and figuratively) for science and science understanding became a national obsession. This movement influenced politics, national affairs and prompted the development of rigorous curricula that would ensure students' understanding of science and therefore reclaim our collective status as the world's leading nation (French, 1986; Swartz, 1991). The "race to the stars" played out our national interests on a world stage and focused efforts on the cultivation of scientists with a very specific goal/mission.

As described above, the "new" science crisis is a high-stakes endeavor of a different sort. A critical difference between calls for reform of the mid-Twentieth Century (Bush 1945; French 1986; Lopez & Schultz 2001; Swartz 1991) and those in the last decade and a half (Rutherford & Ahlgren, 1999, Department of Education 2002; NSF 2002) is the explicit identification for who is included in the educational process. Earlier reforms focused on the development of a relatively few well trained scientists. While science was viewed to be in the service of all society, only a fraction of society "needed" to understand scientific content and participate in its development. Currently, we are concerned with every member of society developing a mastery of science, not in order to become scientists, but to help each individual identify how and why scientific knowledge helps each of us do the ordinary, the everyday, even the mundane. The National Commission on Mathematics and Science Teaching for the 21st Century states that, "No citizen of America can participate intelligently in his or her community or indeed conduct many mundane tasks without being familiar with how science affects his daily life and how mathematics shapes her world" (2000, pg. 14).

The National Commission further states that mathematics and science impact the public in three substantive ways. Science and mathematics are said to (a) have great explanatory power—they teach us that our world is not capricious but predictable; (b) continually shape and reshape our history and culture; and (c) provide human beings with powerful tools for understanding and reshaping the physical world itself. These features are not relegated to a few elite researchers, but rather are qualities necessary for all citizens to substantively participate in our society.

While a fair amount of discussion has centered on school-based learning, another avenue for promoting children's educational development has been in the after-school environment. Relatively recently, educational researchers have been examining the academic benefits of children's participation in after-school educational programs (Cole 1996; Garner, Zhao & Gillingham, 2002; Schauble & Glaser, 1996).

In this chapter, a sociocultural framework (Cole, 1996; Wertsch, 1991*)* is used to illustrate children's development of academic discourse/scientific knowledge while participating in a non-school learning setting. We begin with a brief description of the socio-cultural perspective, where we focus on learning in context, concept formation (everyday and scientific), and the role of language as a tool for learning. Next we provide a general description of the “Science and Tech Club,” an after-school program designed as a hybrid space for promoting children’s mastery of science and scientific language. Following the program description, four excerpts from video-taped recordings of the Science and Tech Club are analyzed. We focus on children’s concept formation (everyday and scientific) and construction of academic discourse. Finally, we address how research conducted in non-school settings can support school-based learning and how such analysis informs teaching and learning more generally.

Sociocultural Theory

The central thesis of the cultural-historical school is that of the social origins of human thinking (Vygotsky, 1978). This school argues that one’s thinking develops through participation in culturally mediated, practical activities. As Scribner (1990) has described, the concept of the mediation of human actions (including thinking) is central to Vygotsky's theorizing, perhaps its defining characteristic. People interact with their worlds through cultural artifacts, especially language in both its oral and written forms, and these artifacts serve to mediate our interaction with the world and develop higher order cognitive skills. That is, the mediation of action plays a crucial role in the formation and development of human intellectual capacities (for instance, the learning or development of science). In this way, human thinking must be understood in interaction with social contexts -- a counterpoint to the traditional American psychological orientations that view the individual as the exclusive focus of study (unit of analysis and locus of treatment/intervention).

From a socio-cultural perspective, competencies are cultural phenomena – products of the individual and the social context in interaction. Therefore, the appropriate unit of analysis is the individual in interaction with others while engaged in a specific activity. From this theoretical perspective, full understanding of an individual's learning is dependent upon the understanding of the context in which learning has taken place (Rogoff, 1994). Furthermore, for Rogoff (1997), actions need to be analyzed in context by examining "how children actually participate in sociocultural activities to characterize how they contribute to those activities. The emphasis changes from trying to infer what children *can* think to interpreting what and how they *do* think." (Rogoff, 1997, p. 273, original emphases). The social organization that influences learning is broader than the physical setting or location for learning. Here, Dewey's conception of a learning situation is useful. He states that, "What is designated by the word 'situation' is not a single object or event or set of objects and events. For we never experience nor form judgments about objects and events in isolation but only in connection with a contextual whole. This latter is what is called a 'situation'" (1938, p. 66-67).

And despite psychologists' efforts to reduce the study of objects or events in isolated or abstracted fashion, Dewey argues that "in actual experience, there is never any such isolated singular object or event; *an* object or event is always a special part, phase, or aspect, of an environing experienced world – a situation . . . There is always a field in which observation of *this* or *that* object or event occurs" (1938, p. 67). We believe that understanding the social organization (supportive of or resistive to learning) is useful to (science) teaching and learning in all environments, including schools and classrooms. Therefore, one central concern for science educational reform is the question, "How can we organize the social activity to maximize student learning?”

Scientific and Everyday Concepts

In educational research and pedagogy, scientific knowledge refers to the understandings of concepts within a science discipline. However, within the socio-cultural theoretical framework, scientific concepts are *not* bound by discipline (science, history, art, etc.) but refer to a larger body of understanding which refers to all concepts that are formally learned through directed practices (Van der Veer & Valsiner, 1994). This broader connotation has led some to refer to scientific concepts as academic or scholarly concepts, reflecting their introduction into the school environment. Conversely, everyday concepts are spontaneously developed as one experiences the world and interacts with other persons on a daily basis. These concepts are not part of a collectively formalized system. Scientific concepts, in the Vygotskian sense, are non-spontaneous.

Individuals hold both scientific and everyday conceptions regarding the phenomena surrounding them. Mathematical or physical formalisms (e.g., a circle is the collection of all points in a plane equidistant from a given point in the plane, or **F**=m**a**) are scientific concepts (of mathematics and physics principles). Similarly, everyday concepts are less formalized (a circle is the round thing that everyone knows about, or when I push on an object it starts to move). Thus, one could offer two distinct descriptions of the movement of a car. One explanation is that when petroleum combusts, its chemical energy is exchanged for mechanical energy (driving a piston). The energy is transmitted through the drive train and gears to apply a torque to the wheels that begin to rotate. Given friction between the tire and the road, the car begins to accelerate forward (with drag from the air). Or the same phenomenon described in a more everyday conception is that when I push down on the gas pedal (or accelerator), the car moves forward.

The relationship between scientific and everyday concepts has been long debated and continues to hold much relevance in contemporary discussions regarding learning and development. When Vygotsky wrote on concept formation, he was concerned with addressing the two predominant views at the time. The first drew no distinction between scientific concepts and everyday concepts (Mahn & John-Stiener, 1998); whereas, the second, presented primarily by Piaget, distilled one from the other. Piaget (1929/1979) proposed that the development of everyday concepts was pre-requisite to the understanding of scientific concepts as foundations for new thought, but not necessarily integral to the new scientific conceptualizations. From these perspectives, Vygotsky formulated his own position. Vygotsky's central question was how children's learning changes upon entering school, that is, understanding the nature of learning and its relation to development. Through his examination of the interrelations of scientific concepts and everyday concepts, Vygotsky theorized dynamic processes: scientific and everyday concepts are constantly unfolding and being influenced by the other. Vygostky wrote:

> The development of scientific concepts begins in the domain of conscious awareness and volition. It grows downward into the domain of concrete, into the domain of the personal experience. In contrast, the development of spontaneous concepts begins in the domain of the concrete and empirical. It moves towards the higher characteristics of concepts, towards conscious awareness and volition. The link between these two lines of development reflects their true nature. This is the link of the zone of proximal and actual development. (1934/1987, 220)

As van der Ver (1998) states, Vygotsky "argued that scientific concepts are dependent on everyday concepts in the sense that scientific concepts presuppose everyday concepts as their foundation, but that scientific concepts in their turn, are able to transform everyday ones" (p. 91). Thus, scientific and everyday concepts may be different but they are not independent of each other. A distinction between non-spontaneous (scientific) and spontaneous (everyday) concepts is useful only to the degree that division is fruitful. Far more attention has been given to Vygotsky's distinction between scientific concepts and everyday concepts than has been given to the interrelation he described between them (Mahn & John-Steiner, 1998). This dichotomization ignores Vygotsky's view of scientific and everyday concepts as aspects of a unified process of concept formation.

Understanding the relationship between scientific and everyday concepts is significant and important in light of current educational efforts to make school subjects (scientific concepts) subjects (e.g. science) more "real-life-like" (everyday concepts). For instance, schools are settings in which the majority of the curricula and academic objectives can be categorized as non-spontaneous, scientific concepts. Indeed, what school environments routinely do is "compress" real-life experiences into six and a half hour intensive session -- schooling is a non-spontaneous (and rather unauthentic) enterprise. School accelerates learning episodes at the rate and scope not afforded in a genuine (real life) context and draws attention to phenomena (scientific concepts) that may go unnoticed. Relying exclusively on schooling to teach science can leave children with abstract, amorphous "knowledge" that they perceive as useless. The purpose of school becomes that of preparing for future schooling and testing. A link to "real life" (and its implied utility for real life) is a key element that stimulates current educational reform efforts within science education. After-school settings provide hybrid and potential alternative spaces for such learning.

In the case presented here, we examine one particular after-school site, the Science and Tech Club. By suspending the typical constraints of classrooms and school experiences (e.g. time, mandated curriculum, etc.), we can focus on children's science knowledge development and appropriation of academic discourse through their manipulation of scientific (non-spontaneous) and everyday (spontaneous) concepts. For Vygotsky, spontaneous concepts "develop through the child's practical activity and immediate social interaction;" whereas, scientific concepts develop with the child's "acquisition of a system of knowledge through instruction" (1934/1987, p. 168). We specifically designed the Science and Tech Club as an environment that blends the scientific and everyday worlds in dynamic manner – a hybrid space, one which re-organizes social interaction in order to create an activity which maximizes student learning.

The Science and Tech Club

The University of California San Diego (UCSD) Science and Tech club is an after-school activity modeled after the Fifth Dimension Project, a long-standing program that originated at the Laboratory of Comparative Human Cognition at the University of California, San Diego. As with all Fifth Dimension sites, the UCSD Science and Tech Club is designed to improve the literacy of pre-college aged children, and in this case, focuses explicitly on improving student attitudes toward and abilities in science, mathematics, and technology. The Club borrows from the Fifth Dimension structure by explicitly creating an environment in which (a) the university and community collaborate in creating a joint activity, (b) university members promote and study learning in pre-college environments, (c) child participation is voluntary, (d) activities are a purposeful mix of play and learning, and (e) the roles of the multigenerational participants (children, college students, and community staff) fluidly change (Cole, 1996; Gallego & Blanton, 2002).

The Science and Tech Club generally follows a constructionist approach (Papert, 1993) that places children as the central agents and constructors of the educational projects. Furthermore, the Club emphasizes the social and contextual nature of student learning (Scott, Cole & Engel, 1992). That is, we recognize that it is not fruitful to separate student learning from the context in which it occurs; context is not simply a backdrop for student learning. Rather, context is intrinsic to student learning; it shapes and is in turn shaped by both the content and the student.

Science and Tech Club participants represent a wide range of age and expertise (in children and university students). Typically the Club (housed in the local Boys and Girls Club) is attended by about ten children and staffed by one community staff employee, and three to five university students. The children range in age from 5 to 14 years. At least one of the participating university students is a content expert, an undergraduate or graduate student in physics or engineering. These content experts are enrolled in one of two courses designed to support their interest in teaching and learning science. Each elective course (either *Physics 180* or *Electrical and Computer Engineering 198*) is a blend of content study (physics or electrical engineering) and study of student learning in these domains. In addition to meeting twice per week on the university campus, university students are required to engage in field-based teaching experiences. The university students' field-based teaching occurs in a variety of sites, after and during school, formal and informal environments. They interact with students of various ages who are enrolled in community college or high school classes or are participants in after-school programs such as the Science and Tech Club. Additional staff support in the Science and Tech Club is provided by the community partner and by university undergraduates enrolled in other (non-science-based) field courses, such as the *Practicum in Child Development.*

Children have the opportunity to participate twice per week in the project-based work of the Science and Tech Club. Participants collectively agree upon the objects of study, and engage in structured real-world activities that mix play and learning (e.g., building strobe lights or throwing water balloons). The projects vary in scope and duration from single day activities (e.g., making light bulbs with nichrome wire) to multi-week projects (e.g., building voice-activated strobe lights) dependent upon the complexity of the topic and the extent of children's interest and commitment.

While the university students who participate in the club change quarterly according to their course enrollment, the children's attendance in the Club is relatively consistent, though voluntary. This exchange of experienced for inexperienced university students provides children with genuine opportunities to teach novice Club participants (the university students and new peer members) the roles and responsibilities of the local Science and Tech Club culture. In addition, each course-quarter rotation provides a natural break for the shift in content. Each quarter, the Science and Tech Club members focus on one content-based theme, such as electricity and magnetism (circuit design and assembly), robotics (systems design and programming), or states and properties of matter (phases, temperature and pressure). The data analyzed below are taken from a quarter when the club members studied mechanics (forces and motion).

For the purposes of this chapter we have selected an excerpt in which the verbal and non-verbal interaction illustrates participants' (both university students and community children) use of everyday (spontaneous) and scientific (non-spontaneous) concepts in the process of learning about physics concepts (Newtonian mechanics).

Scenario I: Mechanics: Forces and Motion - Discussion

In the following, we designate adult participants by the use of the letter "A." A1 is a graduate student in psychology and A2 is an undergraduate senior in engineering. Child participants are designated by the letter "C." The participating children include C1, an 11-year old Hispanic boy and C2, a 9-year old Anglo boy.

On a day when the children are learning about the scientific concepts of Newtonian mechanics (force, mass, and acceleration), the activities begin with a demonstration by the university students. Children observe A1 throw an air- filled balloon to A2 and then A1 leads a discussion about what would happen if the balloon were filled with water. This group discussion is designed to introduce children to the concepts of mass and acceleration, and set up the activity that follows, tossing water balloons back and forth.

A1: How is he [A2] going to prevent it [a water filled balloon] from popping?

C1: Catch it softer.

A1: Catch it how? Softer… With a softer what? His hands will be softer?

C1: It will be softer.

[…]

C2: Oooh . . . He can sort of like… he can sort of like move back and catch it . . . [hand movement of catching over distance]

C1: It could be like running down the street and the speed will get lower . . .

A1: So what causes . . .

[…]

A1: The speed . . .

C2: No the speed going lower.

Here, A1 introduces the scientific concepts of force, and acceleration by use of everyday concepts (throwing a water balloon and preventing it from breaking). While it is not clear what C1 means by "catch it softer," the clarifying comments "move it back and catch it" refers to the reducing the force applied to the balloon. (Whether over a short distance or long distance, the amount of work [force integrated over distance] required to reduce the balloon's kinetic energy to zero is constant. Hence, if the distance is greater, the force applied to the balloon is smaller and the likelihood of popping the balloon is lower.) Secondly, the statements by C1 and C2 reflect an understanding about acceleration, "speed getting lower." That is, there is some important system property other than speed, namely, the change in speed that is significant in the balloon toss. Furthermore, this seems to relate to the popping of the balloon, or in a more scientific conception, relates to the force applied to the balloon.

A few points are worthy of highlighting. First, the children tend to explain the phenomenon correctly using their everyday experiences and language. Even advanced level university students fail to make the distinction between the concepts of velocity and acceleration (L. McDermott, 1993; diSessa, 1993). Furthermore, children's use of their own words to describe physical phenomena before assigning the scientific concepts, illustrated in this example, resonates strongly physics education reform, "idea first, name afterward," (Aarons, 1990). The activity of throwing balloons is simultaneously everyday, familiar, and playful. Despite learning formalized physics concepts, children are doing so in a manner which is familiar and which builds on their collective experiences in the world.

Scenario II: Mechanics: Forces and Motion - activity

Later that day, children are assembled in dyads outdoors. They are given both air-filled balloons and water-filled balloons. They are encouraged to mess about and discover the properties of each of the balloons. Children are prompted to throw the water balloons back and forth to one another and to keep them from popping.

A1: C1. I want you to catch it and do what you can to reduce the force so it doesn't pop.

[A1 tosses balloon to C1, C1 walks back as he catches it]

[other balloons are tossed, one breaks]

A1: C3, what are you gonna do to prevent it from popping… how can you reduce the acceleration? Who can help him out, how can you reduce the acceleration . . .

C6: [raises hand] walk backward!

In this later episode, the adult overtly uses scientific concepts/language. Both the words "force" and "acceleration" are used in relation to the activity at-hand. Furthermore, students are problem solving in practice. Ultimately, no other balloon breaks, and students are walking backward and moving their arms as they catch to reduce the applied force to the balloons. Also evident in this scenario, the club discussion begins to include more children. Students who had not previously contributed to the class discussion now present answers that had been mentioned in the prior scenario, "walk backwards."

In this excerpt, adults not only use the scientific concepts of "force" and "acceleration," but also students are responding to the adults in scientifically appropriate ways. The answer that is provided "walk backward!" still uses everyday language, but does so in a fitting manner, one that is consistent with the physics solution. In this environment, it is not expected that children would answer with the scientific conception in physics: increase the distance over which the balloon is decelerating which reduces the net acceleration to the balloon and hence minimizes the applied force.

Scenario III: Mechanics: Forces and Motion – Recap

The following week, participants revisit the water balloons activities. Students are asked to report back on what happened. After discussing properties of what made balloons pop or not pop, the class examines the concept of "force" in more detail:

A1: The more force you get. Moving back caused what to happen?

[discussion of popping balloons and what causes it…]

A1: …so force is based on acceleration and what else?

C3: Speed?

A1: Well that's part of the acceleration…

C1: Mass! Mass!

A1: Mass, good.

C4: Mass is the weight!

The adult once again leads a discussion using scientific concepts. In this excerpt, the terms "force," "mass," and "acceleration" are used. In this environment students are encouraged both to play with their spontaneous conceptions of physics, to guess or to mess about creatively, and to blend these with the use of scientific concepts. Scientific concepts are injected into the discourse both by the adult (in this case the adult introduces the concepts of "force" and "acceleration"), and by the students themselves (as with the case of introducing the concept of "mass" in a scientific manner). At some points it is clear that students are guessing: "Speed?" In other statements, children begin to use the scientific conceptions. C1 and C4 both use the scientific concept of "mass," a term not found in their everyday lexicon. C1 appropriately answers "mass" when the adult is fishing for answers, but it is not clear what level of mastery C1 possesses. C4 elaborates, relating mass to an earlier discussion about weight. While this is not the strict scientific conception, it is an often-used approximation.

Scenario IV: Mechanics: Motion/ Newton's Third Law— Another Discussion

Later in the same day, students learn about Newton's Third Law: for every action, there is an equal and opposite reaction. At first the children are told that this is what they will be learning about. They are told that ultimately they will build their own model hovercrafts. Then the adults provide a demonstration of the Third Law by connecting an inflated balloon to a straw that has a right angle bend in it. The straw is placed on a pin so that it will freely rotate in the plane with the right angle bend in it (see Figure 1). The balloon is inflated, and then the air releases from the balloon, causing the balloon/straw apparatus to rotate about the pin. In this figure, the balloon rotates counter clockwise in the plane of the page. After an initial discussion about what they observed, the following conversation occurred:

Insert Figure 1 about here

A1: How is that an example of the Third Law?

[kids shout out dozens of words/phrases]

C: It was moving in motion…

C: Action! Reaction!

A1: What's the force?

C: It's the opposite reaction

A1: What's the force?

C: I don't know

C: The air!

C: Air!

C: Yes!

A1: Air from where?

C: The balloon!

A1: Good. The air that gets pushed into the balloon is released and then what happens?

[…]

[The demonstration is run a second time.]

C1: Whatever direction the straw is pointing, it's gonna go the opposite.

A1: Ok it's gonna go the opposite way, why?

C1: Because the air is coming out and it’s pushing it that way. <motions left and right with his hands to show the moving air>

C3: The air inside the straw and it pushes out and <hand spinning to emphasize> I can feel the air pushing out.

[…]

C3: Because the straw was bended and the air sprayed out and it pushed it the opposite way.

Unlike the organization of earlier activities, the scientific concepts and terminology (Newton’s Third Law) were presented first, followed by a demonstration designed to motivate and develop the underpinning physics concepts by using everyday language. Following the demonstration, A1 asks children to describe what happened. They are cued by the adult to explain using scientific concepts, “How is that [demonstration] an example of the Third Law?” It is relatively safe to assume that until this discussion the children had no association with the “Third Law.” As if socially scripted, students begin shouting out as many scientific concepts as they can remember. Clearly little else is meant by children’s use of the terms, “Action! Reaction!” C1 admits not knowing what the “force” (which moves the balloon in a circle) is after having answered with a scientific concept, “the opposite reaction.” With another demonstration, and some leading conversation, student responses become more detailed and address why the balloon is moving, students begin to use their everyday concepts to describe what is happening. In so doing, they demonstrate an understanding of the underpinning physical principles. C1 accurately describes the what is happening in the demonstration and why, “Because the air is coming out and it’s pushing it that way.” His use of “pushing” and his hand gestures are everyday conceptions that demonstrate his understanding of Newton's Law. Child C3 describes what is occurring in his own words, "The air inside the straw and it pushes out and … I can feel the air pushing out." Earlier in this segment each of these children stated the scientific concepts with no understanding of the physical principles. As they begin to use everyday concepts, the group collectively begins to develop an understanding of the fundamental and complex physical principle, Newton's Third Law.

Discussion

The data above and general organization of the Science and Tech Club emphasize three broad effects of discourse in creating educational environments: 1) The development of children: Science Discourse/Knowledge, 2) The Recognition of a Discipline: Science, and 3) The Development and Design of Social Organization: School Science.

The Development of Children: Science Discourse/Knowledge.

The verbal play evident in participants' interactions provides evidence of the importance of language as one of the key tools with which we come to understand (Vygotsky 1978, 1987; Wertsch, 1985, 1991). In the episodes above, children's verbal interactions with peers and more capable adults illustrate the use of everyday concepts and scientific concepts in the process of learning. In discussion of children's development of higher order cognitive processes, Vygotsky (1978, 1987) concentrated primarily on what he called "psychological tools," the meaning-making potential of systems of signs and symbols (most significantly language) in mediating thinking. Pontecorvo (1993) summarizes this Vygotskian idea of tool mediation:

> Mediation tools include the semiotic systems pertaining to different languages and to various scientific fields; these are procedures, thought methodologies, and cultural objects that have to be appropriated, practices of discourse and reasoning that have to be developed, and play or study practices that have to be exercised. (p. 191)

In the case of the Science and Tech Club, children use language to develop their understanding of physical phenomena. Children develop the concepts of force, acceleration, and mass by using scientific and everyday conceptions of the phenomena under investigation (tossing balloons). Furthermore, in so doing, students develop a language common to their community, the Science and Tech Club, which in turn reinforces the community. In no other communities within the Boys and Girls Club does an adult ask a child, "How is [a spinning balloon] an example of the Third Law?"

Vygotsky emphasized a double function of language, how it serves as a means of communication and how it comes to mediate intellectual activity. As a means of communication, language enables human beings to socially coordinate (or dis-coordinate) actions with others through meaning. The children in the Science and Tech Club use specialized language (e.g., force, acceleration, or Newton's Third Law) to structure and coordinate ideas and activity. With the internalization of this communication, language comes to mediate intellectual activity through the discourse of inner speech. The development of this capacity for self-regulation through inner speech is what helps bring actions under the control of thought, a development to which Vygotsky assigned great importance (Wells, 1996). In the Science and Tech Club, through the use of everyday conceptions and language, children begin to develop an understanding of scientific concepts. These concepts help them learn new concepts (e.g., developing an understanding of force facilitates their understanding of Newton's Third Law) and regulate their own action (e.g., understanding a bit about force allows students to talk about and shape how they engage in everyday activities, preventing balloons from popping).

The Re-cognition of a Discipline: Science

Our analysis here focused on how children's interaction surrounding activities and science topics prompted their use of everyday (spontaneous) and scientific (non-spontaneous) concepts to develop an understanding of science content. We argue that it is in these moment-to-moment discoveries made by each child that a re-formulation, or re-cognition, of the educational discipline of science is developed.

The development of the science discipline requires a much broader lens and expansive view over a substantively longer period of time than we discuss presently; yet, the excerpts provided here illustrate conceptual development of science by children. That is, the child's perception, appreciation, and wonder of and for science change. For this child, what counts as science has changed; it no longer is limited to a school subject. With the arousal of each child's interest in learning "about" science is the potential for continued motivation and interest to "do" science. As educators, we must reconsider how and what we define (count) as "school science." The learning that takes place in environments such as the Science and Tech Club, illustrated here, requires us to recognize the importance and the very necessity of everyday concepts in the development of scientific (schooled) concepts. Based on the interrelationship between everyday and scientific concepts, we can support efforts to recontextualize school science to incorporate epistemological, affective, and motivational elements.

Discussions regarding the utility of everyday understanding and everyday concepts for the development of students' scientific (schooled, non-spontaneous) concepts in the discipline of science have found a new and eager audience. Educators toil to link school with the everyday *as a means* for supporting school learning (*the end*). However, we contend that the relationship between everyday and scientific concepts is not unidirectional. What we wish to underscore is that everyday and scientific concepts are inter-dependent. As presented above, children use everyday concepts to learn the scientific. This relates to the scientific concepts being rooted in the everyday. However, once scientific concepts are developed, they are in turn used to understand the everyday. Indeed one of the main purposes of scientific conceptions within science is to understand the everyday phenomena. Scientific concepts (even the discipline of science) are challenged, encouraged, provoked, and legitimated by everyday concepts. The Science and Tech Club builds upon this understanding in order to recognize the value of scientific concepts, the disciplines in which they are embedded, and use them to explore the world of the students.

The Development and Design of Social Organization: School Science

Studies in ecological psychology have documented that the physical features of a setting and how people participate in such environments are related (Gump, 1978; Gump & Good, 1976). That is, the site or setting for learning influences what and how something is taught or learned (Johnson, 1985). Clearly there are characteristics of the school setting that influence content and how teachers and students participate in these settings. Features, such as compulsory attendance, standardized curriculum and mandatory assessment, and high student to adult ratio, can either be viewed as positive/supportive or negative/non-supportive influences to a particular curricular goal.

The participants of the Science and Tech Club acting *within* a non-school setting generate the interactions described and analyzed in this chapter. Both tacit understandings and physical characteristics that collectively comprise this unique learning situation support the social organization of knowledge in this setting. While the physical attributes of the Science and Tech Club are relatively easily identified (located in a room at the local Boys and Girls Club, tables not desks, participants of varied ages, etc.) these attributes also influence the development of more tacit features regarding session involvement and Club membership. For instance, children's voluntary participation can exert both negative and positive influences on the site's social organization. Positively, children voluntarily elect to participate based on their interest in the topic and motivation to advance their understandings of science. Such attitudes and motivation result in an atmosphere in which participants have a common investment and are therefore "members" of the club community. One's club membership requires a certain degree of responsibility (e.g., students are required to act safely, attentively, and participate regularly) as well as the provision of special and reserved "rights" (e.g., students who do not act safely or are not regular participants are not allowed to work on the more advanced and multi-day projects, such as building strobe lights). On the other hand, voluntary participation has the potential to negatively influence understanding of science. Inconsistent attendance can pose particular challenges and pedagogical concerns regarding topic selection, lesson pacing, and assumptions about children's prior knowledge. Each of these instructional issues in turn influences the environment's climate and level of risk-taking, intimacy, and ambiguity the participants can tolerate while still achieving success in the setting.

Conclusion

It is commonly stated that schools are environments that de-contextualize information in ways that make the information abstract and difficult to learn (Lave, 1988). However, various researchers (Cole, 1996; Rueda, Gallego & Moll, (2000); R. McDermott, 1993; Rogoff, 1994; Van Oers, 1998) emphasize the importance of context for all forms of meaningful concept formation (including abstract concepts). Rather than describing school learning as de-contextualized, what is actually taking place is the process of re-contextualization (Van Oers, 1998). Another form of re-contextualization is the use of "out of school" environments for learning the type of content that may be considered abstract and school-like (scientific) concepts.

Currently, after-school learning environments are being examined with great interest for their potential in supporting school learning (Garner, Zhao & Gillingham, 2002; Schauble & Glaser, 1996). Furthermore, some researchers are interested in how after-school settings can inform our educational revision, restructuring, and reform. Schauble and Glaser (1996) noted the appeal of out-of-school environments as context for educational research:

> Many classroom researchers have found it instructive to rethink the design of classrooms in light of what works in out-of-school learning environments. Because of the constraints of these environments are somewhat different from

> those that operate in school, informal learning contexts can serve as laboratories for testing innovative approaches to learning.(p. 9)

As attractive as this direction for educational research is, Resnick (1991) tempers educational researcher's enthusiasm by cautioning that simply removing one's self physically from the school setting does not ensure a distinct social organization. Rather, educational activities (e.g., tutoring science camp), commonly held in a non-school location, (e.g., Boys and Girls club, Parks and Recreational facilities) may very well replicate in-school interactions. Without deliberate attempts to change respective roles within such arrangements, participants are likely to maintain their adult/child responsibilities as teacher and student, regardless of the physical setting. Resnick argues that change in the social organization of/for learning requires a qualitative and dramatic change in the relationship between participants.

We agree with Resnick and believe that care should be taken in advocating any educational program if its merit is based simply on its physical location. Yet, we also think that educators can build on Resnick's cautionary statement, to advocate that it is possible to use the after-school environments to restructure school practice. That is, it is possible to import, transfer and replicate the patterns of interaction and the collaborative relationships found in some out-of school programs (such as the Science and Tech Club). In this light, there are promising examples of recent science educational reforms (Klentschy, Garrison, & Amaral, in press) that seek to develop children's scientific concepts and their understanding of the science domain.

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Figure 1: Balloon / Straw set-up for Newton's Third Law activity