

# Hands On!

A publication for mathematics and science educators

Fall 2001 Volume 24, Number 2



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Bay Odyans: Argumentation  
in Haitian Creole Classrooms

Extending Mathematical Power:  
It's Not Just Kid Stuff

Karen in Motion

The Logic of Everyday Languages

## Understanding

# Diversity

In Science and Mathematics

By Ann S. Rosebery and Beth Warren

**F**irst and second graders watch a toy car roll down a ramp. The students, in this economically and racially heterogeneous classroom, are working to develop qualitative descriptions of the car's motion, specifically, changes in its speed as it moves down the ramp. Sharrone, a child who has rarely spoken since the first day of school, volunteers, and holds the floor for nearly ten minutes as he explains what he thinks is happening. Using an analogy to describe the car's motion, he imagines a bike going down a high hill, going faster and faster, not able to stop, hitting a passerby near the bottom of the hill and sending her to the hospital. His teacher asks him to explain why the bike might hurt the passerby, anticipating some account of the bike's fast speed. Sharrone responds with more elaborate details of the event, explaining how the bicyclist and the

*(continued on page 4)*



Photo: Amy Snyder, ©Exploratorium

# TERC Names Dennis M. Bartels New President

The Board of Trustees at TERC have appointed Dennis M. Bartels as the organization's new president. He joined TERC on July 26th from the Exploratorium, an interactive science museum in San Francisco, where he was director of the Center for Teaching and Learning.

"TERC is making a serious contribution to a critical agenda in education," Dennis said upon his appointment, "demonstrating that all students are far more capable of learning than current thought and systems of education suggest. The rigor of TERC's research in testing the value of its ideas and products, and its commitment to experiment and innovate, are in my view, the best in our field. Now more than ever, TERC's voice must be heard in the national dialogue on how best to improve student learning outcomes."

Under Dennis's leadership, the Exploratorium pioneered the first teacher induction program unique to science teachers and established a national center for staff developers seeking to improve their inservice programs for elementary school teachers. Previous to joining the Exploratorium, he directed a statewide education reform initiative and led curriculum and instructional reforms at the South Carolina Department of Education. Dennis holds a doctorate of philosophy in education from Stanford University and completed his undergraduate degree at the University of North Carolina at Chapel Hill.

Dennis succeeds Barbara C. Sampson, whom TERC honored for her 12 years of service and dedication to the organization. TERC staff and trustees warmly welcome Dennis, confident that his broad experience in both formal and informal education have prepared him well for the task of leading TERC into its 37th year and beyond.

# Contents

"Learning for all students," "No child left behind." These familiar slogans hold high ideals and goals. They are simple statements attempting to rally energy and resources to confront a problem that is not simple.

This issue of *Hands On!* focuses on TERC's research efforts to understand why some students get left behind and how classrooms can change to engage all students in rigorous science and math learning. In each case presented here, there is one common factor: a teacher striving to create opportunities for learning and to provide an environment where students can demonstrate what they know and can do. For the teachers, this involves the minute by minute task of trying to hear and understand their students. It is in this process that the teacher identifies the strengths and resources each child can use to further his or her own learning.

In the cover article, Ann S. Rosebery and Beth Warren discuss factors that influence how we hear and understand students, particularly students with backgrounds different than our own. It is an introduction to the research and to the detailed stories of student learning we present in this issue.

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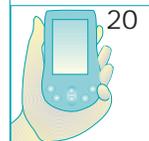
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All opinions, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the funding agencies.

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passerby did not see each other. The teacher attempts to engage Sharrone in identifying the bike's speed as the reason the passerby at the bottom got hurt. Pointing to the ramp, she adds a passerby near the top and asks Sharrone who is going to be hurt more. Sharrone identifies the passerby at the bottom but does not refer to the car's faster speed as the cause. The teacher then asks other children for their view of who is going to be hurt more. Allie responds by saying that the one near the bottom will be hurt more because at the top the bike is just getting started and so is really slow, but when it's near the bottom it has a longer time to speed up, making it harder for the bike to stop.

Sharrone and Allie have different ways of understanding and responding to their teacher's question. Sharrone, an African American child from a working-class family, tells a story from multiple perspectives, that of a bicyclist riding down a hill and that of a pedestrian walking across the biker's path. At the heart of his story are phenomena central to kinematics: an immediate sense of the bike's speed as increasing as it goes down the "high hill...faster and faster," the difficulty of stopping in time the farther one goes down the hill, and the impact of a collision at the bottom of the hill. He uses these phenomena to define the drama of his story's unfolding events. Allie, a white child from a middle-class family, uses the ideas and events in Sharrone's story to construct an explanatory account, from the perspective of an outside observer, that centers on the time it takes for the bike to speed up.

Despite recent reform efforts in science and mathematics education to involve all students in rigorous learning, it is still the case that many students do not get opportunities to participate in this kind of learning. The talk of an African American child who conveys his ideas about science in the form of a story is often seen by educators with majority, "mainstream" perspectives as somehow less "scientific" or "mathematical" than the talk of a white child who conveys her ideas in objective, propositional language. In this article we use Sharrone to represent children who are not necessarily seen as academically successful and Allie to represent children who are. Many of us involved in current reform efforts in science and mathematics, while aware that responses like Sharrone's and Allie's differ from one another, struggle to recognize the contribution each makes to learning. Why do we—teachers and researchers—tend to hear Allie's talk as more "scientific" than Sharrone's?

## Images of what counts as "scientific"

One factor is our expectation of what counts as an acceptable response to our questions, which is conditioned by our sense of what constitutes scientific or mathematical reasoning. Allie's talk conforms to the conventional image of what good scientific thinking and talk sound like. She speaks directly to the subject the teacher has in mind—the changing speed of the bike—and provides an explanation for it based on the time the bike has to speed up. It is easy, given a certain set of assumptions about what it means to "talk science," to appreciate and recognize the scientific value of her focus on time in relation to the bike's speed as accounting for the greater injury to the person near the bottom of the hill.

## Familiarity with children's ways with words

A second factor, which intersects with the first, is our degree of familiarity or unfamiliarity with children's "ways with words" (Heath, 1983)—their ways of organizing their experience and expressing meaning. An elaborate story full of intimate, layered detail about the circumstances of a collision between a bicyclist and a pedestrian seems somehow far removed from the main task, to build an account of changes in a toy car's speed as it moves down a ramp. What does such a story have to do with constructing an explanatory account of accelerated motion, we ask ourselves? Indeed, Sharrone's story includes the fact that the hill is high and the bike gets faster and faster as *background* to the main event, whereas Allie features these as the *main topic* of her account. It is easy for many of us to miss this background as we try to sort out the relevance of the richly detailed events he is narrating. By the way he organizes this information in the setting of the story, Sharrone assumes it is old knowledge, information he already shares with the teacher and other students, and therefore it does not bear emphasizing. In addition, if we examine his story closely we see that it is grounded in big ideas in kinematics, such as acceleration and momentum. In fact, the detailed and dramatic scene Sharrone creates, which implicitly features time in relation to speed, seems to help Allie construct her account around the idea that the bike is hard to stop when it nears the bottom of the ramp because it has more time to speed up.

In general, schools acknowledge and use only a limited range of the kinds of talk and thinking that children use in their everyday lives (Heath, 1989; Lee, 2000). This narrowness has the effect of marginalizing much of what children learn in their homes and communities as irrelevant to school; children from low-income, racial, linguistic, and cultural

minority backgrounds can be particularly disadvantaged by this narrowness inasmuch as the school has seemed especially “unable to recognize and take up the potentially positive interactive and adaptive verbal and interpretive habits learned by Black American children (as well as other nonmainstream groups), rural and urban, within their families and on the streets” (Heath, 1989, p. 370). What opportunities are missed when we do not know how to see the strengths in the talk and reasoning of Sharrone? Neither Sharrone nor Allie has the opportunity to go deeply into the other’s ideas and sense-making practices, to see how these relate to those of science (e.g., imagining oneself into phenomena, constructing explanatory accounts), and to appropriate these for their own purposes as learners.

As educators, we are daily faced with the challenge of learning to recognize and appreciate the intellectual and communicative strengths of children who say and do things in ways we either do not know how to value or find confusing (Cazden, 1988; Foster, 2000). Many factors can determine whether we are able to recognize and appreciate a child’s sense-making resources. We may have trouble understanding her if she grows up speaking a first language or a dialect different than our own; if she comes from a household of a different educational or socioeconomic background; if she grows up in a community that embraces different social and communicative traditions and values; and so on. Teachers and researchers do not misunderstand children intentionally. Instead, misunderstandings arise because we have not yet learned to recognize and appreciate the diverse sense-making practices that children deploy as they work at understanding scientific or mathematical ideas and practices. We do not know how to understand their out-of-school ways of talking and knowing; nor do we know how to see the connections of these to the ways of talking and knowing that carry academic value for us. As Cindy Ballenger (1999, p. vii) has written of her experience teaching Haitian pre-schoolers: “I began with these children expecting deficits, not because I believed they or their background were deficient—I was definitely against such a view—but because I did not know how to see their strengths.”

### Researching children’s scientific and mathematical sense-making

For the past 13 years, staff researchers and teacher researchers at the Chèche Konnen\* Center at TERC have worked to document the powerful intellectual and discourse traditions of

children typically marginalized by school science and mathematics. We have explored how the oral and literate traditions of low-income, racial, linguistic, and ethnic minority children relate to scientific and mathematical sense-making (Ballenger, 1997; Rosebery, Warren & Conant, 1992; Warren & Rosebery, 1996; Warren, Ballenger, Ogonowski, Rosebery & Hudicourt-Barnes, 2001). This work has involved us in a continual process of reflection on the assumptions each one of us brings to this work based on our histories, in particular, assumptions about language, culture, and science. Such a perspective is needed if, as educators, we are to understand the intellectual traditions and sense-making practices of children who do and say things in ways we do not expect or know how to value.

Our examination of student talk in bilingual (both Haitian Creole and Spanish) and urban English-speaking classrooms has also led us to ongoing study of research in the history and social studies of science (Biagioli, 1999; Goodwin,

**NEW PROJECT**

**Chèche Konnen Center receives new grants**

With funding from the National Science Foundation and the Spencer Foundation, researchers at the Chèche Konnen Center will pursue a set of questions that grow out of past work. Collaborating with teacher researchers in Cambridge and Boston, the Center will study and document pedagogical practices designed to harness the diversity in children’s ideas and ways of talking as an intellectual resource in science. The design work will focus on making this diversity an explicit theme of discussion and inquiry in the classroom. In both bilingual and heterogeneous classrooms, children will investigate the different ways they and others—teachers, texts, scientists, family, and other adults—use language to construct accounts of scientific phenomena, whether arguments, narratives, explanations, models, or the like. The aim of this research is to develop an understanding of how all children, as they develop understanding of scientific ideas, also learn to see “inside” the ways in which language and other symbol systems can be used to construct and represent knowledge about the physical and biological world. The goal is for all children to develop command of a broad and deep repertoire of ideas and sense-making practices useful in learning science and, more generally, in making sense of their experience in the world.

\*Chèche Konnen means “search for knowledge” in Haitian Creole.

1997; Ochs, Jacoby & Gonzalez, 1996). These studies, in their detailed analysis of the everyday work and talk of scientists, support a greatly expanded, and perhaps surprising, view of scientific practice. This view goes beyond emphasis on hypothetico-deductive reasoning and theory-building and everyday experience as a form of misconception to one that includes vigorous argumentation and highly situated guesswork. Rather than seeing informal language as inadequate to the task of precise description, explanation, and modeling, it recognizes innovative and expansive uses of everyday words to construct new meaning, as well as imaginative ways of entering into the phenomena and processes one is trying to understand. Our study of classroom talk and the research literature on professional scientific activity have broadened our sense of what counts as scientific reasoning and activity and deepened our understanding of the kinds of intellectual and discourse practices that support robust, rigorous scientific thinking.

### Examples of Chèche Konnen research in *Hands On!*

In this issue of *Hands On!* we present three portraits of what we are learning from this work. Josiane Hudicourt-Barnes discusses some of the ways that *bay odyans*, a familiar discourse practice in Haiti, can serve as a resource in arguing scientific claims and evaluating evidence in the classroom (p. 7). Tracey Wright shows the role that bodily experience of motion played in a third-grade girl's emergent understanding of distance, time, and speed ("Karen in Motion," p. 12). And in "The Logic of Everyday Languages" (p. 16), Cindy Ballenger examines how a Haitian American sixth-grade boy used his everyday language in both Haitian Creole and English to formulate nuanced

distinctions of the concepts of growth and development. Each portrait documents what it is possible to see when one looks closely at the talk and ideas of children who do not fit the school's typically unexamined norms of what counts as intellectual work and scientific reasoning.

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## RESOURCES

For more information about the Chèche Konnen Center's research, visit the Center's web site at [www.terc.edu/cheche\\_konnen/](http://www.terc.edu/cheche_konnen/).

Center staff have produced several resources for educators. These include the professional development video series *Sense Making in Science* and its companion book, *Boats, Balloons, and Classroom Video*, by Ann S. Rosebery and Beth Warren. Available from Heinemann, 800-793-2154, [www.heinemann.com](http://www.heinemann.com).

Also, Cynthia Ballenger tells her account of three years teaching Haitian children in an inner-city pre-school in *Teaching Other People's Children*, an award-winning book from Teachers College Press, 800-575-6566, [www.teacherscollegepress.com](http://www.teacherscollegepress.com).

RESOURCES

“**T**he bathrooms in Haiti have mold, the bathrooms here don’t get moldy,” asserts Manuelle, a sixth-grade student. A classmate challenges her claim and an animated discussion ensues in which Manuelle must defend her position.

The activity in the classroom and the energy the students commit to the discussion might appear chaotic to some teachers. Manuelle’s teacher, however, is used to these discussions. The teacher of a transitional bilingual class for Haitian students, he has come to see the importance of these science talks in supporting his students’ learning.

The students are quite comfortable and confident in challenging statements and arguing with their peers. Their confidence comes from their everyday life experiences. Argumentative discussion is a major feature of social interaction among Haitian adults and can be seen in the way people in Haiti *bay odyans* (“to give talk”). Bilingual teachers participating in the Chèche Konnen Center’s teacher researcher seminars have found that this form of discussion—*bay odyans*—can be a great resource for students as they practice science in ways that draw on adult modes of scientific investigation.

Argumentation is an essential skill in the development of scientific knowledge (Latour & Woolgar, 1986). In any scientific endeavor the researcher, working within a theoretical framework, constructs claims based in evidence developed through scientific practices such as experimentation, fieldwork, historical reconstruction, or modeling. Arguments are what scientific research is all about: searching for knowledge, presenting a position as fact, and defending and redefining that position in the face of challenges.

Although contested in some educational quarters, I argue that the oral traditions of Haitian culture connect deeply with those of the Western academic world. In a culturally familiar environment, Haitian students can participate in animated arguments about scientific phenomena in a way that is integral with Haitian culture and fully congruent with a scientific search for meaning.

## Bay Odyans as Preparation for Scientific Research

Consider this quote from *Medicine and Morality in Haiti* by Paul Brodwin (1996):

Every day scores of public buses leave Port-au-Prince bound for the provincial towns of southern Haiti. Conversation is impossible for the first hour as the bus crawls through the impossibly congested neighborhood of Kafou.... Finally breaking free of the urban sprawl, the bus picks up speed.... Cooled by the fresh mountain air, this is when people—total strangers when they boarded the bus—start to talk.

The first exchange I remember went something like this. A woman sighs loudly and thanks Jesus, but someone else breaks in with a pointed joke, “It wasn’t Jesus, it was our driver who saved us.” “But we are all children of God,” responds the woman amid scattered laughter. Then an aggressive voice pushes the debate further: “Are you a child of God? Then why do you say that we Catholics worship the devil?” A murmur stirs the passengers.... The first speaker protests, “No, it’s not all Catholics. But there are those who deal with “other things.” The conversation then explodes into a free-for-all about the sincerity of converts to Protestantism and about Catholics who are morally upright as opposed to those who need “other things” (p.1–2).

The social event Brodwin describes—*bay odyans*—is a favorite Haitian activity. A form of entertainment to the participants, the animated discussion may seem like a fight to non-Creole speakers. Although the literal translation of *bay odyans* is “to give talk,” it can also be translated as “chatting.” In a chat, however, there is a certain focus on the relationships of the people involved. In *bay odyans* the focus is on the words or the stories.

I propose that *bay odyans* is a linguistic event in which participants take on certain roles. During *bay odyans*, a

speaker voluntarily or involuntarily takes the role of a theoretician and makes a statement. The theoretician is followed by a challenger who excites the rest of the group and provokes laughter and expressions of surprise or enthusiasm. An argument follows in which divergent points of view are supported or disputed with evidence or logic. In most cases, the argumentation is punctuated by funny interjections, laughter, and theatrical gestures.

The theoretician or proponent of the idea has the burden of remaining calm while defending a point. Throughout the argument the theoretician supports a claim with evidence or the force of logic and eventually may modify the claim. The challenger's role is often more theatrical and is directed toward both the theoretician and the audience. The challenger's counter-argument is considered both a tool for arriving at the truth and an entertainment for the audience. The other members of the group may watch and goad the group for a while or take over one of the two main roles.

### Investigating Mold

The class discussion about mold that I referred to earlier is one of several examples the Chèche Konnen researchers have documented that support the claim that Haitian students, even children in the early elementary grades, are skilled at argumentation. The discussion emerged as students tried to draw inferences from their life experience about where mold will or will not grow. The students had been observing mold grow on slices of bread in the classroom. The following excerpt, translated into English, was recorded in Haitian Creole. I include my interpretation of the interaction in parentheses.

Manuelle: The bathrooms in Haiti have mold. The bathrooms here don't get moldy. (offers a generalization)

[whoops and commotion]

Ernst: Oooo, How come the bread gets moldy? (challenges statement using counter-evidence)

Teacher: Children, let me say something, she said the bathrooms here don't get moldy, you say you don't agree. Explain. (restates the challenge to the generalization)

Ernst: How come the kid said that her bread got moldy? (restates his challenge)

Teacher: She is not talking about bread, she is talking about bathrooms. (redirects conversation)

Ernst: Bathrooms get moldy. (offers counter generalization)

Manuelle: Not everybody's. (wants the generalization narrowed)

Teacher: Explain, explain.

Manuelle: Does the bathroom downstairs grow mold? (offers evidence for her point)

Ernst: No, because they clean it. (accepts her point with reserve)

Manuelle: Well, that's what I'm saying. The bathroom at my house does not have mold because I clean it. (takes it as a point in favor of her argument)

[commotion]

Jerry: Mr. I, the reason it doesn't grow mold in her house is because she always cleans it. You should do an experiment. Do not clean the bathroom, do not clean the shower curtain. The curtain will have mold. The curtain will grow mold. (offers a possible experiment to settle the issue)

Pierre: It always makes mold. Every time it makes mold, they clean it. (predicts results)

Manuelle: Sometimes I am asleep, my mother wakes me up to clean the bathroom. (offers an explanation of why her bathroom will never have mold)

Manuelle originally said that mold doesn't grow as much in U.S. bathrooms as in Haitian bathrooms. The students find that claim fun to confront, and Ernst assumes the role of challenger. The teacher serves as a moderator, acknowledges that there is a conflict, and encourages Manuelle to defend her position. Jerry offers a plan for an experiment that he thinks will disprove Manuelle's claims. She narrows her claim to say that mold doesn't grow in clean bathrooms and makes sure everyone is aware of her own ability to keep her bathroom free of mold.

The students in this example are engaged in authentic scientific thinking and discussion of scientific phenomena. The teaching and learning environment provides them with an opportunity to build on their knowledge, beliefs, and skills in ways that are similar to those of scientists. Their teacher does not assume that his job is to know all the answers and ask all the questions. Instead, the students theorize with the teacher, ask questions, explore the meanings of their questions, make claims, and offer evidence and arguments to support their claims. All of this can happen because the teacher respects the knowledge and sense-making resources of the students.

## Researching the Achievement Gap

Some research examining the gap between academic achievement of linguistic minority students and their mainstream peers assumes that the sense-making resources of children from diverse linguistic and cultural communities differ from those needed for science. The claim is that the differences present a barrier to learning that must be overcome by instructional means. Much of the methodology for this research assumes that asking children from diverse communities the same question will yield similar responses. But, as has been amply demonstrated by sociolinguistic research, questions and other verbal interactions are interpreted differently depending on social context. Labov (1972) argues that “the social situation is the most powerful determinant of verbal behavior and the adult must enter into the right social relation with a child if he wants to find out what a child can do.” A child’s silence and lack of response may have its own particular meaning. The interpretation of silence by the interviewer is subjective and can hardly be considered scientific evidence.

Research employing this type of methodology, a standard question and answer format familiar to most middle class students, has resulted in negative descriptions of Haitian students’ ability to do science (Fradd & Lee, 1999; Lee & Fradd, 1996; Lee, Fradd & Sutman, 1995). In an analysis of data from interviews with Haitian students Lee et al. (1995) associated the poor quality of the children’s responses to features of Haitian culture. For example, they describe cognitive strategies of Haitian students in this manner:

Haitian Creole students displayed a pattern of strategy use different from that of the other three groups (Latino, white Anglo, Black English speakers). Instead, they used more incipient strategies, such as observation and imitation. . . . The students also used nonverbal signals such as looking down, hiding their faces with hands, or displaying long pauses. . . . Haitian Creole students reported little use of strategies. They appeared not to understand the question of strategy use, or responded on several occasions with “Nothing” or “No” (p. 808).

Lee et al. further claim that patterns of interaction that are culturally congruent with Haitian culture could be considered inconsistent with the norms of discourse and task engagement in science.

We must question research that shows a whole ethnic group as incompetent—that is, lacking language and cognitive skills—in thinking scientifically. What assumptions about Haitians and Haitian Creole are behind the research analysis? What assumptions did the researchers make as they developed their methods? Educators need to look for evidence of competence in situations where children are able to display what they know and what they can do. Children coming from Haiti may not have strong school skills because of the weaknesses of the educational institutions in their home country. This does not mean that Haitian students lack skills necessary for science learning. When allowed to display what they know and can do, these students exhibit resourcefulness in applying skills grounded in their culture’s oral traditions. Rather than being inconsistent with the norms of scientific discourse, these skills are in fact deeply congruent with the practice of authentic scientific research.

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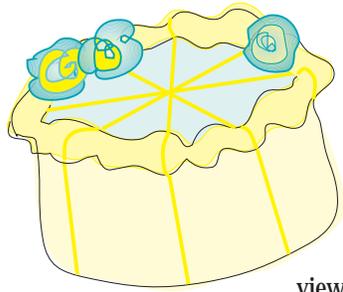
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# Extending Mathematical

By Diane E. Ready

# POWER

—It's Not Just Kid Stuff



**M**any adult learners who claim they “can’t do math” may view math as too difficult or not relevant

to everyday life. For them, memories of math class conjure an image of worksheets filled with unsolved equations, a panic-inducing jumble of numbers and symbols. These same adults undoubtedly use math in their everyday activities without recognizing it—as they mix baby formula, make change, or hang wallpaper. The Extending Mathematical Power (EMPower) curriculum, under development at TERC, plugs into adult learners’ experiences and strategies to feed their understanding and agility with formal mathematics.

The EMPower curriculum extends concepts drawn from three standards-based K–12 mathematics curricula to reach out-of-school youth, adults, and other non-traditional students in pre-GED, GED/high school equivalency, and transitional courses. Developed by teachers and researchers with expertise in adult mathematics and K–12 mathematics reform, the curriculum is aligned with recently issued standards and frameworks for adult mathematics education.

## Making It Real

Martha Merson, a research associate for EMPower explains, “Our philosophy is to bring down the curtain from the mathematical ‘Wizard of Oz.’” Myriam Steinbeck, project co-director, adds, “We start from the premise that students have understandings that they bring into the classroom. We can take the mystery out of mathematics by posing problems that have intrinsic contextual relevance and by connecting to students’ experiences and intuitions.

Making math relevant may help maintain the interest of adult learners, many of whom sandwich classroom time between work and family responsibilities. The initial chapters of each unit ask students to engage in open-ended exercises, such as interpreting graphs from newspapers and magazines or brainstorming to categorize uses of computation and estimation in their everyday lives. As units unfold, the real-life context is woven through the investigations. For example, students determine the perimeter of the classroom and draw

it to scale; they chart where their clothes are manufactured; or they explore large numbers by finding how many 10s, 100s, or 1000s are in a lottery award of \$3843.

## Fueling Discovery

The curriculum departs from the traditional approach to adult education that directs learners through pages of workbook problems at their own pace. Mary Jane Schmitt, project co-director, explains, “The EMPower curriculum encourages people to work together. . . . We try to exploit differences that students bring to the classroom to develop communities of mathematical investigation and discourse.”

“We address the range of levels among adult learners in a class by asking students to share different ways to solve a problem. Teachers use that information to point students to increasingly efficient strategies to reach an accurate solution. For instance, to determine how many items are in a 5 by 10 array (a block of 5 rows with 10 items per row), some students might count by 1s, some might count by 5s and some might multiply 5 by 10. Ultimately, multiplication is faster, but the group exercise can deepen everyone’s understanding of how counting, addition, and multiplication are related.”

Steinbeck observes, “We want students to see that they can depend on their own thinking, not on someone else’s magic formula. Group problem solving highlights which strategies are most comfortable for individual learners. . . . The teacher’s role is to help learners become efficient problem-solvers while continuing to make sense of the mathematics.”

## Seeing Thinking in Action

The need to make student strategies and thinking audible and visible shapes investigations, classroom discourse, and homework throughout the curriculum. Open-ended investigations and frequent opportunities for written and oral expression create a window onto student understanding and progress.

Traditional curricula that use correct calculations as the sole measure of mastery of a topic can mask gaps or richness in understanding. Schmitt cites the example of a student who

knew the formula to determine area and had excellent computational skills. “We thought he really knew the topic until class investigations revealed that he saw area as a formula but did not understand that area could also be measured by counting the number of square units in a shape. He expressed amazement not only that he had not grasped area as a concept, but also that others could determine area without the formula.”

## Extending Literacy and Numeracy

While basic math is traditionally thought of as numerical calculation, the EMPower curriculum encourages narrative as a tool for students to explore, review, and internalize concepts. Steinback explains, “We always leave room for people to say and write how they get an answer. Since so many adult learners have literacy issues as well, this process develops writing skills, and offers a different lens on what people understand.”

In response to a question about how students use geometry and measurement in everyday life, one student responded:

I have to cut a big sheet of brownies or cake every day at work. The size of the sheet pan is about 2 feet in length and 1½ feet wide. Each pan of brownies or cake, I have to cut it ten by seven. Which will give me 70 square little pieces. I think each one of those pieces measures about 2 inches by 2 inches.

Merson observes, “The student response shows she has a picture of area. She has working knowledge of units like feet and inches and she seems to understand that squares are equal on all sides. This is valuable information for the teacher. When she needs to convey a concept to this student, she can revisit the kitchen-related example to clarify concepts and operations as the unit progresses.”

## Learning by Doing

The EMPower curriculum emphasizes a hands-on approach. In “Many Points Make a Point” students not only analyze and interpret data from graphs they bring to class, but students also collect and organize data to generate their own graphs. Steinback notes, “Just as writing helps you read, generating a graph improves your ability to interpret graphs.”

As students progress through units, they incorporate math vocabulary, concepts, and skills as they make connections between math and everyday life. Toward the end of the “Many Points Make A Point” unit, students are asked to generate and categorize data on the foods that they eat; create a plot line, bar graph, and circle graph; and include statements on what the graphs say about their dietary balance. Merson comments, “This

multifaceted exercise reveals whether the student ‘gets it’ in ways that would not be discernable through traditional multiple choice comprehension assessments. The hands-on approach creates more active consumers and producers of information.”

## Field Testing Underway

Three units of material developed for pre-GED level classes are being field tested in five states. “We are evaluating the curriculum and revising pilot lessons based on actual classroom experience,” explains Schmitt.

The EMPower team is working toward developing eight units with hands-on activities and assessment not typically available to teachers who seek to embrace new standards.

Steinback notes, “We realize that our approach to adult math learning may take more time, but this is the way the concepts will stick. It will enable students to think, reason, and problem solve with their peers and individually as their teachers listen, guide, and probe.”

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*This article is based on interviews with Martha Merson, Mary Jane Schmitt, and Myriam Steinback.*

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## Features of Every EMPower Investigation

-  A clear mathematical goal
-  A context that engages adult learners
-  Mathematical concepts and skills that are important for adults to know
-  Opportunities for learners to strengthen math language by communicating with the teacher and each other
-  Steps and directions that are simple to communicate
-  Various ways of entering and solving the problem, valuing the diversity in adult education classes
-  Puzzling force—The problem draws students in and provides enough interest to motivate learners to seek a solution

# Karen in Motion

By Tracey Wright

**Karen** is in third grade at an urban public school near Boston. She is not academically confident or regarded as a strong student by some of her teachers. In fact, in certain settings, she is labeled learning disabled. Despite the varied view of her abilities, Karen has had the opportunity to grapple with key mathematical concepts related to motion.\*

Karen's learning was supported by a teacher, classroom environment, and content area that allowed students to use their first-hand experiences of motion (running, walking) to build an understanding of the mathematical world of motion. Karen's teacher, Ms. Dee, encouraged students to explore motion physically and to use movement and gestures to interpret representations of motion. She designed activities that required students to communicate about the motion they were studying. She introduced representations of motion, whether conventional (charts and graphs) or idiosyncratic (pictures or roads made of dots) as tools for describing a particular motion to someone else.

Students continually alternated between enacting and representing linear motions. This allowed the students to get inside each new representation and connect it physically and conceptually to motion.

Although the significance of kinesthetic learning (the use of one's bodily perceptions in learning) in K–12 mathematics has not been extensively explored, teachers of young children have always recognized the importance of allowing children a variety of ways to express themselves. Non-traditional forms of participation can encourage students, especially those who might not otherwise participate, to enter academic conversations (Ballenger, 1997; Gallas, 1995; Warren & Rosebery, 1996). By encouraging physical enactment, Ms. Dee provided another way for Karen and others in the class to participate in the exploration of the mathematics of motion. It also allowed Karen to use physical enactment, a significant intellectual resource for her as she developed a deep conceptual understanding of distance, time, and speed—knowledge that is critical to further study of the mathematics of change (see sidebar, page 13).

## Investigating Three Motion Stories

In developing her motion unit, Ms. Dee, an experienced teacher, collaborated with Chèche Konnen Center staff at TERC. She also drew on her experience with the Center's intensive seminar in which teachers and researchers did science and science-related mathematics together and explored students' ways of talking and knowing in science and math. In addition, Ms. Dee used an investigation from *Patterns of Change*, a fifth grade unit in *Investigations in Number, Data, and Space* (Tierney, Nemirovsky, Noble & Clements, 1998) as a resource for ideas and activities.

As part of the Center's research, staff videotaped Karen's class and interviewed students. I have selected examples from the videotaped sessions and interviews I conducted with Karen to show how she uses physical enactment to develop her mathematical understanding of motion.



Figure 1. Karen demonstrates two different walking speeds.

### Example 1: The Race

Consider the problem: Two people start at the same place, at the same time, and move along a straight line path (about 9 meters long) as if they were in a race. Given the motions described in Stories 1 and 2 below, who would win and why?

Story 1: Walk slowly about halfway, and then run to the end.

Story 2: Run about halfway, stop for 2 seconds, then walk to the end.

I present this problem to Karen during an interview that took place early in the unit. I ask her who she thinks will get to the end first. She says confidently “the first guy,” because the second guy “would have to stop for 2 seconds.” In predicting the outcome of the race, the 2-second stop is a deciding feature for Karen. This is one reasonable interpretation, but I wondered if Karen could think about whether and how the race could happen differently. I ask her to show me a “walk” and a “walk slowly” as a way to question her implicit assumption that the walking speeds in Stories 1 and 2 are the same. Karen goes over to a line of tape Ms. Dee placed on

\*All names are pseudonyms.

## Mathematics of Change

Many educators would argue that the Mathematics of Change is too difficult for elementary students to understand, or at best, is for students in enrichment programs. However, understanding how events, organisms, populations, or physical phenomena change over time (i.e., the mathematics of change) is critical to understanding the world around us. One important context for studying the mathematics of change is motion, the relationships among distance, time, speed, and acceleration. Studying motion allows students to observe their own physical experiences through a new mathematical lens, connecting them to a variety of powerful representations. By learning to look through this mathematical lens, students can begin to understand patterns of change not only in their classrooms but also in the world around them, and to develop ideas about functions and graphing, which are emphasized throughout the K–12 Algebra strand of the National Council of Teachers of Mathematics (NCTM) standards. Furthermore, the NCTM (2000) Principles and Standards state, “If ideas of change receive a more explicit focus from the early grades on, perhaps students will eventually enter calculus with a stronger basis for understanding the ideas at that level.” The Math of Change research group at TERC has been studying ways in which students’ kinesthetic experiences are related to their understanding of motion; in particular to their understanding of graphs and across a variety of mathematical environments. To learn more about their research visit [www.terc.edu/mathofchange/Moc/](http://www.terc.edu/mathofchange/Moc/).

the floor for the unit. She walks along the tape demonstrating two slightly different speeds (see Figure 1). As she finishes, she says that the first guy would still win, “unless that [second] guy did the same speed as the running. Then it would be a tie. . . .He’d have to powerwalk. . . .They’d both have a good chance.”

Initially, Karen seems certain that “walk” versus “walk slowly” will not affect the result of the race. By enacting a walk versus a slow walk, however, she broadens her notion of what a walk is. She realizes that a walk must be defined in relation to other motions, such as other walks, a run, or a powerwalk. Karen comes to think about stories 1 and 2 as a set of possibilities, not as a fixed set of instructions that lead to one right answer. The fact that she considers more than one way for the race to be enacted signifies that she is developing a more thorough understanding of the relative nature of speed. She ponders how variations in speed might relate to each other, and how they could affect a race’s outcome.

### Example 2: Hansel and Gretel

Midway through the 20-session motion unit, Ms. Dee introduces her own version of the classic Hansel and Gretel story and poses the following question:

When they [Hansel and Gretel] were running they left bread, but it got eaten. So instead of leaving bread, let’s pretend they left rocks behind. And they were running really fast. And they left a rock behind every ten minutes. The witch took all the time in the world and she left rocks behind too. And she walked really, really slowly and she dropped a rock behind every ten minutes. I want you to think about this as a challenge and a puzzle. Which rocks would be closer together? The witch’s or Hansel and Gretel’s?

Karen responds quickly and incorrectly to Ms. Dee’s question; one that can be difficult unless you “get inside” the event itself. Ms. Dee calls on other children, most of whom represent Hansel and Gretel’s trip by “walking” their fingers along an imaginary straight line on the floor. One hand moves quickly, while the other hand moves at a slower speed to represent the witch’s trip. Ms. Dee comes back to Karen, giving her a chance to explain her previous answer. Envisioning the trip, she uses her hands this time to show the location of the dropped rocks. She says and shows that if Hansel and Gretel were running very fast, the rocks would be “far apart” (see Figure 2a); but if they were running medium fast, the rocks would be “medium together.” If the witch were

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Look for “Karen in Motion: The role of physical enactment in developing an understanding of distance, time, and speed” by Tracey Wright in the *Journal of Mathematical Behavior* (vol. 20, no. 2). The forthcoming article provides a fuller discussion of the factors contributing to Karen’s learning.

Two papers based on the case of Ms. Dee’s class are available from the Chèche Konnen Center: “‘Why would run be in speed?’ Artifacts and situated actions in a curricular plan,” by G. Steve Monk, and “‘What are we going to do next?’ A case study of lesson planning,” by Ann S. Rosebery. Contact [cheche\\_konnen@terc.edu](mailto:cheche_konnen@terc.edu).



Figure 2a.



Figure 2b.

*Adopting a different perspective to answer the question, Karen uses her hands as dropped rocks to help envision the relation of speed to distance in the problem.*

walking really slowly, the rocks would be “closer together” (see Figure 2b). By using her hands, Karen is not simply imitating the other children. She adopts a different perspective to answer the question. Gesturing, she models what the rocks would look like after they had been dropped on the road, as if she were hovering above the road, looking down.

By using her hands to compare the patterns made by the location of the rocks, Karen demonstrates that she knows that the spaces between the rocks indicate something about the speed at which the traveler is moving. But how exactly does this relationship between speed and distance work? Does farther apart mean faster or slower? Talking through her answer, Karen tests out an expectation she has about how different speeds would look in terms of their interval distance. It is worth noting that, unprompted, she adds a third speed—medium fast—to the story, perhaps to further test her own understanding. She proposes not just a dichotomous answer (fast is far, slow is close) but something more along a continuum—the faster the racer, the farther apart the rocks or the greater the interval distance.

### Example 3: Number Table of a Car Trip

One of Ms. Dee’s goals is for her students to learn some conventional mathematical representations involving distance, time, and speed. She introduces these towards the end of the unit, in the same way she introduced other representations the class worked with, as ways of communicating about particular motion trips. In class the week before, Karen and her partner Barney had been given a standard ruler in inches and a “road” with dots on it representing the motion of a car. Ms. Dee explained that each dot marked where a coin was dropped every five seconds along the car’s trip. From that they created a motion story and a number table of the car’s trip. Ms. Dee was concerned that Barney had done most of the work; we both wondered what Karen had understood about this rather formal representation, a multi-column number table.

In an interview, I ask Karen to tell the story of the car’s trip using the table that she and Barney had made the previous week (see Figure 3). Ms. Dee had given the students blank tables with column headings and intervals of 5 seconds filled in under the “time” column. The headings of the table were titles that the class had developed and agreed upon. (Another way to understand these headings is to think of “Distance between drops” as speed, “Distance from start” as position, and “Speed change” as acceleration.)

Karen begins the story of the car’s trip by pointing to the 0 in the “distance between drops” column, saying that that was the start. Then she says, “the distance between drops got to 8, so, say, a car, it got faster.” She adds that going from 8 to 8 means the speed didn’t change. “It stayed 8.” She says that 8 to 7 means the car is slowing down. When I ask her how she knows the car is slowing down, she says confidently, “because it was 8 and now it’s 7.” She tells me that the distance from the start is 23. She points to the “distance from start” column and gets out her dot road, explaining that they measured the distance between each dot with a ruler and counted the number. She then points to the 1 in the speed change column (next to the 23) and says that means the speed changed “like only one thing about it. It’s getting slower.” I ask how she knows it changed by 1, and not by 2 or 3. Using her hands to indicate a small fixed interval, she says, “Because the ruler showed us what it did (gesturing a small fixed interval with her hands).” A few moments later, she describes the overall story of the car’s motion. “It’s fast, then it’s going slower (gesturing all the way down column 1). Say the car’s like running out of gas.” As I point to each number she says that it starts out fast, then “gets slower and slower and slower and slower and slower and slower and slower until it just stops. It stops right there (pointing to the 1 in the last entry in the distance between drops column). Because there’s nothing else!”

Karen’s story of the car’s trip clearly indicates that she understands how the numbers in the table reflect the car’s motion. She shows me how she envisions slower speed, that is, the car covering smaller distance intervals in the same time interval, in much the same way she modeled speed in the Hansel and Gretel example. She uses a similar gesture (as in Figure 2), to indicate that the car’s interval distance decreases as it slows down. Karen’s sense of speed is clearly grounded in her gestures; they form an important part of how she conceptualizes the number table. At the same time,

TIME	DIST. BETWEEN DROPS	DIST. FROM START	SPEED CHANGE
0	0	0	0
5	8	8	+8
10	8	16	0
15	7	23	-1
20	6	29	-1
25	5	34	-1
30	4	38	-1
35	3	41	-1
40	2	43	-1
45	1	44	-1
50	1	45	0

Figure 3. The number table, constructed by Karen and Barney, represents the story of the car's trip. (Students' table redrawn.)

her understanding is clearly symbolic: she uses the columns of numbers to envision the road and the dots and thus the motion of the car's overall trip.

### Thinking Symbolically with Movement

Karen uses knowledge gained through physical movement not only to solve the problem in front of her, but also to conceptualize a broad mathematical territory. In the first two examples she worked through the conceptual issue that any one motion (run or walk) can have a variety of speeds, and that these differences (walk vs. walk slowly) can affect the outcome of a race in predictable ways. In the first example, she figured out how time was affected when she manipulated speed as distance was held constant. In the second example, speed affected the distance between the rocks (the slower the traveler, the closer the rocks) as time was held constant. In Example 3, which unlike the others was quantitative in nature, Karen used a multi-column number table to figure out the effect on distance of varying speeds while time was held constant. Together, these examples suggest that by the

end of the motion unit, she was able to move quite fluidly among a variety of motion representations, including a conventional data table.

Working out the relationships between distance, time, and speed with her body, Karen engaged in the kind of abstract and symbolic reasoning that is at the heart of mathematics education. Although physical enactment contributed to her learning, I do not want to suggest that Karen is a "concrete learner," because, in fact, she exhibited great resourcefulness in using motion to reason abstractly. My point, instead, is to highlight the benefits of a bodily dimension to learning, a dimension often overlooked and under-appreciated in mathematics classrooms. "Karen in Motion" reminds us of the often unseen potential in students. Perhaps as more teachers like Ms. Dee examine what it means to teach and learn mathematics and allow students to use their diverse intellectual resources, more students like Karen will have opportunities to succeed.

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# The Logic of Everyday Languages

By Cynthia Ballenger

Most science classrooms rarely allow for students' everyday language. A student's informal or unschooled ways of questioning or approaching a topic are often discouraged because they seem imprecise, silly, or wrong. Even teachers who recognize the importance of including students' own questions and ideas in a class discussion can find it hard to hear the science and the seriousness in the rollicking talk that may result.

The classroom talk discussed in this article is in many ways a rollicking talk. The conversation is about metamorphosis and took place among students in a transitional bilingual classroom (grades 5–8). At first glance, their talk appears to be full of jokes and challenges, which belie the seriousness and depth of the students' thinking. The fact that the discussion was allowed to take place at all is based on the teachers' trust that the students were making sense—even though their comments may have initially sounded silly or off topic. The teachers also trusted that the students could use their first language, Haitian Creole, to think and talk scientifically. This trust emerged in part from the teachers' experience with the Chèche Konnen Center at TERC (see Science Circle, p.17).

By many accounts, as students of science the children in this class are disadvantaged by their first language in two senses. First, their national language is not considered by many as adequate for academic science. Because it is a Creole language not often used for higher education, Haitian Creole is viewed as lacking technical and scientifically precise terms. Many people, including native speakers of Haitian Creole, say that it is better suited for expressing emotion than for scientific explanation. Second, the students' ways of talking, arguing, and presenting information—ways learned at home—are seen as very far from the academic or schooled form of language used in science classrooms. Shirley Brice Heath (1983) refers to these patterns of language socialization and use as “ways with words.” Individuals may speak the same national language, but their linguistic and social practices such as storytelling or argumentation typically occur in different contexts and even assume different forms.

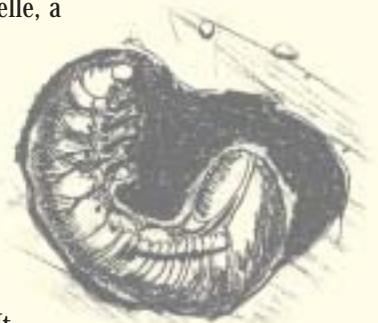
## Negotiating Meanings for Change

The following example from the Chèche Konnen Center's research shows how one student, Jean-Charles, uses his first language in both senses to deepen his understanding of metamorphosis. Both the vocabulary he uses and his way with words help him construct meanings for change, growth, and development, central concepts in biology.

Quiet, respectful, and diligent at school, Jean-Charles has been judged to have difficulty organizing language in both Haitian Creole and English. He therefore receives extra help from a learning disabilities tutor. His drawings, on the other hand, are detailed, full of shading and texture, and greatly admired by his classmates.\*

For several weeks Jean-Charles and his classmates have been watching mealworms move through stages of metamorphosis. In class one day, Manuelle, a student, asks, “Why, if people eat and eat, they don't change their skin, they don't transform, the way insects do?” Her question is prompted by a passage she just read aloud from a text about metamorphosis written in English. It describes the huge amount that larvae eat before they turn into pupae. Sylvio, the teacher, asks the students to comment on Manuelle's question. The students put their books away and get together for a science circle.

One student responds that human skin does peel, a form of changing skin. Manuelle counters, “But we don't transform.” Fabiola says, “God did not create us like insects.” She evidently means, that's why we don't transform. Raoul introduces basketball: “If you play basketball, you get dirty, when you bathe, your skin comes off with the dirt.” He is suggesting that, like the larvae, we too change our skin. Marianne responds, “It's not all people who do that.” Standing, she



\*The drawings in this article were done by Jean-Charles during the period of the metamorphosis discussions.

demonstrates how slowly some old people walk, implying that because they don't play hard, they don't get all dirty and then change some of their skin while bathing. Jean adds that he has learned from television that your skin rubs off inside your clothes. Stefan, a new student, makes a general statement, declaring, "People and animals aren't the same thing."

Jean-Charles then addresses a response to Manuelle and her initial question:

Manuelle, skin changes. It's like, the larva, when it was inside the egg, you, like when you were inside your mother's stomach. It's like, when you were a little baby, when you were born, when you were a little baby, you had hardly any hair. Didn't that change? Don't you have hair?

Jean-Charles' comments cause an uproar. His classmates are eager to respond. Manuelle says that not all babies are born without hair. Marianne wants to distinguish growth from change: "You grow, you don't change," she tells Jean-Charles. Responding to Marianne on the question of change versus growth, Jean-Charles offers, "When you were a baby, your eyes were closed," implying that since they weren't closed anymore, she had changed. Joanne points out that Manuelle doesn't look like she did as a baby—Manuelle had changed. Manuelle listens to this and then stands and exclaims, "Do I change my skin like this, vloop, vloop?" pretending to unzip her skin and climb out of it.

This conversation can be interpreted as a negotiation over what the term *change* might mean in the context of experiences with insects. In an attempt to understand a mealworm's life in relation to their own, the students create a need to sort out what matters in describing insect and human development.

Manuelle sees insects and humans as "changing" in very different ways. Some students claim the opposite. Learning that

humans do slough off their skin (playing basketball or inside their clothes) they argue that in this case human processes and insect processes are the same—humans change skin, insects do, we all do.

Jean-Charles uses change in the broadest sense to refer to any number of differences and developments, such as height, more hair, and open eyes as well as the development from a larva to a pupa and from an embryo to a newborn. According to Jean-Charles, all animals change over time, insects and humans. He seems to see metamorphic change, changing skin, and hair growth as all essentially the same.

Metamorphosis is a particular kind of change, a series of distinct stages; it is not a kind of change that is noticeably gradual and

## Science Circle

The story of how Jean-Charles and his classmates came to participate in science class begins with their teachers, Pat Berkley and Sylvio Hyppolite.

Pat and Sylvio's respect for their students' first language is grounded in a number of experiences, including their participation in the Chèche Konnen teacher seminars. The opportunity to "do science" in the seminar had a profound effect on what Pat heard as "scientific" in the classroom. As a young science student, Pat had not experienced much success so as an adult she continued to see herself as unscientific. In the seminar, however, she found that her questions, which to her sounded silly and unscientific, were taken seriously and contributed in significant ways to her own and others' understanding. She began to see that her way of thinking about the world might have value in learning and teaching science. As a result, she determined to take her students' questions seriously, especially those that sounded "silly" or "unscientific."

The seminar gave Sylvio opportunities to investigate new participation structures in science. Watching a videotape of another teacher's class in which Haitian students vigorously debated a student's claim, Sylvio came to recognize that the discussion was similar in form to those he had witnessed on street corners in Haiti and on the playground with his students. As a Haitian bilingual teacher he was familiar with the energy and skill that many Haitians put into argumentation, but he had not thought of fostering this kind of talk in science class. Together, Sylvio, Pat, and the children created "science circle"—a time for students to share questions and observations, try out theories, and argue claims. It was at times a boisterous event. At all times, science circle was a context in which the students and teachers were able to draw upon their familiar, everyday ways of characterizing, organizing, theorizing, and arguing about the phenomena of the natural world.

continual, like growing over periods of time, as Marianne mentions. Rather, it crucially contains discontinuous stages—“vloop, vloop” and it’s over-and-done. And it follows a reliable pattern—it does not differ from individual to individual like hair growth might or the ability or desire to play basketball. Although not all the students agree on how the terms should be used, they are getting at the basis for the use of the terms *grow* and *develop* in biology, the former with its reference to continuous change and the latter with its reference to reliably patterned transformation from one discrete stage to the next.

In this talk, the students bring their everyday reasoning, and ways of talking and making sense into contact with the issues in science that they are exploring. They speak in their first language, a Creole language not known for its scientific vocabulary. They also talk to each other and in a manner that is more often associated with social situations outside of school. There are jokes and disagreements, references to religion as well as basketball, bathing, and old people. There are physical demonstrations and dramatic enactments, such as Manuelle’s vloop vloop, and Marianne’s slow old-people walk.

The students’ everyday ways of talking and thinking support multiple ways to begin to talk about growth and development. Their familiarity with each other and their deep knowledge of their first language allow them to joke and tease as well as probe meanings and imagine change in insects and in people. An interview with Jean-Charles several months later reveals how he continues to think about these issues.

## Distinguishing Grow and Develop

In this interview excerpt, Jean-Charles describes a beetle. The text includes the original Haitian Creole as well as its English translation to show how he is using the grammar of his first language to help him distinguish the kinds of change in the phenomena in front of him.

Jean-Charles: *Li gen yon pakèt de chanjman. Premye chanjman an se lè l te ti bebe li vin gran epi, dezyèm chanjman an li vin tounen yon “pupa.” Twazyèm chanjman an epi li vin tounen yon “beetles.”*

It has a whole bunch of changes. The first change is when it was a baby it got bigger, then, the second change it turned into a pupa. The third change then it turned into a beetle.

Jean-Charles is saying that the beetle goes through a lot of changes. The larva grows, then it gets bigger. And then after a certain period, it turns into a pupa and then a beetle. He calls all these phenomena *chanjman* (“changes”), reminiscent of his use in science circle of a broad definition of change that includes everything from metamorphosis to growing hair. But here he seems to be making a distinction he had not made before. Notice the words he chooses to make this distinction.

*vin(i) gran* means “become big” and he uses this for growth.

*vin(i) tounen* includes the idea of “becoming” (*vini*) and of turning into or “transforming” (*tounen*), and this he uses for “change to another form.”

He uses *vini* as a part of both meanings and alters the second term to distinguish the kinds of becoming. There are other Haitian Creole words he could have used: he could have used *grandi* (“grow”) for growing bigger, *transfòme* (“transform”) for turn into. But by including *vini* in both phrases, Jean-Charles preserves a sense that, while both “become,” one becomes big and one becomes something else. The changes that he perhaps once regarded as essentially the same, he now sorts into two terms, choosing words that mark the contrast and similarity of the changes.

In Haitian Creole you can place many verbs next to each other in what are known as serial verb constructions. Jean-Charles can say *vini tounen*, literally “become turn into,” and be grammatically correct. It appears that Jean-Charles makes use of this construction in Haitian Creole to explore his developing sense of aspects of change.

Later in the same interview Jean-Charles, of his own volition, switches into English and, in speaking about ants, he uses the English terms *grow* and *develop*.

the eggs develop, um, they, the eggs become, um grow,

the eggs growing bigger bigger bigger bigger bigger til it’s um develop

and when it’s finished it could be a queen or a worker.

Here again, he creatively uses terminology, this time in English, to distinguish the types of change he sees within the processes of one organism. He starts by saying the eggs develop, then backtracks to say they grow, which they do not, although the larvae inside, which can be seen much more readily, do.



The eggs (i.e., larvae) grow “bigger, bigger, bigger.” This they do “till it’s um develop and when it’s finished it could be a queen or a worker.” When he uses “develop” here he is concerned with radical changes of form. He uses what must be for him a past participle, “develop[ed],” focusing on the over-and-doneness of the change. With the next phrase, “when it’s finished,” he doubly marks the sense that the focus in development is on the endpoint. In contrast, referring to continuous growing, he uses a present participle with a comparative “growing bigger, bigger, bigger.” By repeating the comparative, he is clearly focused on the sense of the continuousness, not on the endpoint. During the whole-class discussion, he began by articulating a rather undifferentiated view of change; now he has these two aspects, central ones for biology, existing in some sort of defining contrast.

## Re-Thinking Language Use in Science

Often, and especially in the science classroom, scientific terms are seen as part of the framework of an explanation—they refer to each other in the edifice of theory that they jointly build. For example, it is difficult to understand tension without compression and a theory of forces is implicit in fully understanding them both. Jean-Charles appears to be using, first of all, the language he knows best, Haitian Creole, and then later on English, as a tool to map out the territory of growth and development in a similarly broad and contrastive conceptual landscape. He develops his awareness of these terms in relation to each other and with definitions that he seeks to refine. He moves from an everyday usage to a view which suggests an awareness of language itself. Although Jean-Charles is labeled as a special education student, a bilingual student with particular difficulties with language, here he demonstrates



a creative and subtle way of working with words and meanings. He uses Haitian Creole, and his far-from-complete knowledge of English, to construct ways to think with language about differences in meaning between *grow* and *develop*.

A view of everyday language as unscientific and in opposition to the precision and specificity of scientific terminology does not do justice to how human beings use language to think and to learn. Unfortunately, most schools and society in general tend to hold this narrow view. The story of Jean-Charles and similar stories that are documented in the Chèche Konnen research are helping educators see the value in allowing students to talk about their experiences using the full

range of their linguistic abilities. This research can further challenge all teachers to examine carefully what the children are doing with their first language—in both senses—rather than to assume that jokes or personal experience or everyday words lack intellectual substance or are outside what we think of as rightfully “scientific.”

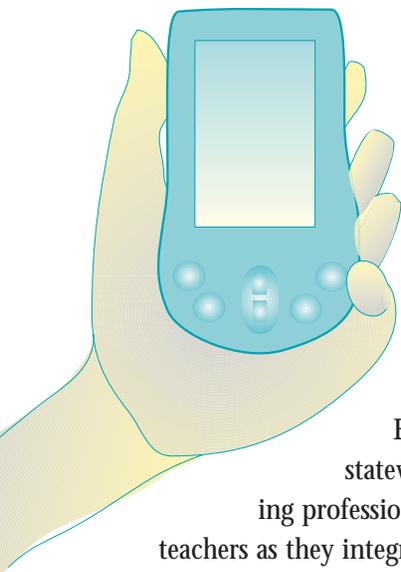
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# High Tech Palm Reading Speeds Project MEET

## P

roject MEET

(Massachusetts Empowering Educators with Technology) is a statewide collaborative project providing professional development to support

teachers as they integrate technology to enhance curriculum and raise student achievement. A critical component of Project MEET is a research effort that is examining the effectiveness of the program and its approach to technology integration. As project researchers began their work, they looked for an efficient way to collect data—appropriately, they turned to technology to solve the problem. As a result, the researchers are now engaged in some high-tech palm reading—using data gathered by Palm IIIxe Personal Digital Assistants (PDAs).

As one of the Project MEET partners,\* TERC trains and supports school-based Technical Professional Development specialists (TPDs), who in turn support the MEET teachers as they implement their technology-integrated instruction. Ideally, a TPD interacts with teachers daily by offering instruction on using various computer software; finding on-line information sources to enhance a lesson; trouble-shooting technical problems; and working with teachers to co-plan and co-teach lessons.

During the first year of the project, TPDs recorded the quantity and nature of these daily interactions using paper and pencil logs, which were handed over to the research team at monthly seminars. According to Bill Nave, director of research and evaluation for Project MEET, “The quantity and quality of the log data were quite inconsistent from month to month. Most of us don’t remember what we had for breakfast by the end of the day, yet we were asking the TPDs to reconstruct a day’s work each afternoon or days later in addition to other responsibilities. As a result, about one-third of the TPDs submitted no data at all during the first year.”

In its second year, the project gave every TPD a Personal Digital Assistant with a customized database and pull-down menus for TPDs to record their daily work with teachers. Entry

options include logging time spent co-planning, co-teaching, conducting a workshop, or providing technical support for events such as computer crashes. Nave explains, “Because it is easy to make the entries, TPDs are entering data on the spot. It is in the same format across entries and across users, improving the quality, consistency, and accuracy of the entries.”

Since the introduction of the PDA, the number of TPDs submitting data has risen from 64% to 88%, and the number of data entries has nearly quadrupled from 1000 to 3900. Because users can beam content from their PDAs to other systems, submission of data is much faster and more efficient. The research team can analyze data without first entering it from paper log sheets, facilitating more timely feedback.

TERC has analyzed the data to track how TPDs’ roles have evolved during the school year. The data show that early in the school year TPDs spent about equal amounts of time providing technical support and curriculum support to their teachers, but later in the year they spent more time on curriculum issues. Research associate Jennifer Sullivan reports, “Teachers are increasingly turning to TPDs for curriculum assistance, such as how to incorporate satellite images from a web site into an ecology unit. As the year progressed the TPDs reported ten times as many entries for technical skill building with teachers than incidents of “fix-it” work, such as changing a printer cartridge. Teachers are clearly seeing the value of a TPD as a teacher rather than as a technician.”

Interestingly, the introduction of the PDA has also created some converts among avowed technophobes. Sullivan recalls one TPD who despaired that she would never “figure out” the instrument when she received it in August. “By the end of September she was raving about it. She used it not only for data collection, but also to coordinate schedules for her entire family.”

The ease of use of the PDAs and the enhanced quality and quantity of the data underscores the thesis that technology, used appropriately, has untapped potential to improve education.

*Project MEET is funded by the U.S. Department of Education #R303A980031.*

\*TERC is one of 13 Project MEET partners that include the Massachusetts Department of Education, four school districts, and other Massachusetts educational organizations. Visit [meet.terc.edu](http://meet.terc.edu).

# New Projects

## **Accessible Mathematics**

This project aims to explore ways that students with disabilities can improve their mathematical learning. TERC researchers are working with an action research group of mainstream classroom teachers and special education teachers to examine how these students learn mathematics best and what is needed to develop their mathematical thinking. Successful strategies will be documented and disseminated widely to other practitioners. Funded by the National Science Foundation.

## **Creating a Sustainable GLOBE Presence in Central Massachusetts**

TERC selected four schools in Massachusetts to join GLOBE, an international program of environmental monitoring. Each school received science equipment and the staff development needed to carry out GLOBE. Fourteen teachers now join more than 40 previously trained GLOBE teachers in the central Massachusetts area as they begin implementing GLOBE in the fall of 2001. During the year they will participate in three additional professional development days focused on GLOBE implementation. Funded by the Intel Foundation.

## **Exploring Earth**

TERC is partnering with publisher McDougal Littell to produce a high school Earth Science program that integrates Web-based visualizations and investigations with a textbook. TERC is creating the web site and an investigations guide. References to the Internet resources will appear at the point of use throughout the text. The program will make extensive use of satellite images, astronaut photos, animations, and advanced visualizations created in-house, delivered in web pages designed with novice technology users in mind. Using the program, students will study Earth as a system

of interconnected components and will experience Earth and space science as a process of inquiry, exploration, and discovery. Funded by the National Science Foundation.

## **KidSmart—WriteSmart—AlphaSmart Evaluation**

TERC will assist Boston Public Schools in the evaluation of its KidSmart—WriteSmart—AlphaSmart program. AlphaSmart functions as a writing pad with the ability to download writing to a computer for further text editing and formatting or to a printer for direct printing. The evaluation will examine whether students in 44 third and fourth grade classrooms report more positive perceptions of, and larger changes in, their writing over the past year, and larger improvements in their writing performance and standardized test scores than do students from the same schools that did not have access to AlphaSmarts during the same time period. Funded by the Boston Public Schools, Office of Instructional Technology.

## **Mars Student and Scientist Partnership Conference**

This conference will explore ways to engage students in authentic Mars research in partnership with scientists. Several educators and scientists interested in experimenting with this new model of science and education will participate. Expectations include developing some long-term partnerships, plans and proposals, and creating a scalable model. The mini-conference will be held at TERC. Funded by TERC.

## **National Conference on the Revolution in Earth Science Education**

This conference brought together key people from government organizations, along with educational leaders, Earth scientists, and others directly involved in policy and practice to explore the changing nature of Earth and space

science education. Participants are developing a comprehensive set of recommendations for using newer elements of Earth science education (such as expanded role of technology, Earth as a system, inquiry-based learning) and other methods to increase the number of students taking Earth science courses. This report will be widely distributed to key educational leaders at the federal level and in all fifty states, the Earth science community, teachers, materials development specialists, and other interested parties. Funded primarily by the National Science Foundation.

## **Networking Education Teacher (NET)-Support**

TERC is developing and pilot testing a Web-based information technology curriculum module incorporating innovative connective hardware and Telnet session sharing software developed by Network Development Group, Inc. The NET-Support package enables students to practice remote network router configuration and problem-solving skills by interfacing with state-of-the-art equipment hosted on the Web. The project will support teacher-users of the pilot curriculum with online mentoring and moderated teacher and student discussion. Funded by the National Science Foundation.

## **VISOR: Visualizing Statistical Relationships**

TERC will work with a group of middle and high school teachers over a three-year period, investigating their understanding of associations between variables and how their thinking changes when data analysis tools are introduced. In the second and third years, participants will teach and do research with their students, based on their continuing work in the seminar. Funded by the National Science Foundation.

## **Setting a Research Agenda: Parents as Informal Math Teachers of their Elementary Grades Children**

TERC organized a conference to craft a national agenda for research in parent-child mathematics. Attending were approximately 30 leaders in this area, including directors of parent involvement and systemic change projects, and experts in family literacy, parent-child research, public policy, and equity.

The conference resulted in a list of crucial areas for future research in parent-child math, suggestions on research approach, and recommendations for utilizing research results in communicating with parents and the public. Recommendations will be disseminated to the educational and research communities and to the National Science Foundation, which funded the conference.

## **On Being Explicit: Toward a New Pedagogical Synthesis in Science**

The Chèche Konnen Center at TERC is intensifying its focus on documenting the intellectual power of the ideas and sense-making practices that children from diverse ethnic and linguistic communities bring to the study of science. Over the next several years, Center staff and teacher researchers will collaboratively design and document pedagogical practices that harness the diversity in children's ideas and ways of talking as an intellectual resource in science. This diversity will be made into an explicit theme of classroom discussion and inquiry. During the project, children will investigate the affordances and limits of their own and others' ways of using language and other symbol systems to construct accounts of scientific phenomena. Funded by the National Science Foundation and the Spencer Foundation.

## **Science for Today and Tomorrow**

Science for Today and Tomorrow will use an assessment-led approach to develop a prototype one-semester, standards-based life science curriculum for grades 5–8. The project will also develop integral professional development materials for teachers, provide support for administrators, and develop mechanisms to further community involvement and understanding. Funded by the National Science Foundation.

## **A Revision of Investigations In Number, Data and Space**

TERC's K–5 math curriculum, *Investigations in Number, Data, and Space*, is being revised to meet the evolving needs of students and teachers, and to take into account the expectations for learning mathematics provided by the NCTM's Principles and Standards for School Mathematics. Major emphases of the revision include: integrating algebra into the curriculum; strengthening the development of number and operations; and creating informative, useable, and comprehensive assessment tools. Professional development materials and components for other audiences, such as parents and administrators, will also be developed. Funded by the National Science Foundation.

## **MarsQuest Online**

TERC, the Space Science Institute, and NASA's Jet Propulsion Laboratory (JPL) are developing MarsQuest Online, an exploration-based web site. MarsQuest Online provides 12 structured experiences to familiarize people with Mars and highlight intriguing questions. The site's guided experiences, tools, and resources will help users define and carry out their own investigations. JPL's participation in the project allows unparalleled access to NASA's image and data archives. To promote the effective use of these resources in an investigation, the tool set includes an Annotator for marking and labeling

images and a Personal Exploration Journal for recording notes and storing personal collections of images. The two-year project is funded by the National Science Foundation.

## **Media and American Democracy Evaluation**

TERC is evaluating the Media and American Democracy program of the Harvard University Program in Professional Education. First offered in 1997, this week-long summer institute has served approximately 500 secondary English, history, social studies, humanities, and journalism educators. The program seeks to (1) deepen participants' understanding of the concepts and ideas related to the use of electronic and print media in our democratic political process; and (2) promote the integration of the latest ideas and research on this topic into participants' instructional practice in order to improve student media literacy. Funded by the Knight Foundation.

## **Handling Calculus: Math in Motion**

The Science Museum of Minnesota and TERC are researching, developing, and testing a set of exhibits with accompanying programs that introduce museum visitors to several central concepts in calculus: graphs and rate of change; integration and differentiation; and the use of sets of equations to provide a simple way to describe complex motion.

This project will also develop a "calculus lab" space and environmental features that encourage visitors to become involved with the exhibits, and establish a youth group that will work to create sculptures based on calculus concepts.

The Charles River Museum in Waltham, Massachusetts, will also host several exhibits and assist with assessment. Funded by the National Science Foundation.

## Schools and Families: Building a Math Partnership

by Megan Murray

A guide to help teachers and administrators implementing the *Investigations in Number, Data, and Space* curriculum address the issue of parent involvement. The first section discusses: barriers, and strategies for overcoming them; hosting math events, from one-time offerings like Parent Nights to seminars that take place over time; the most frequently heard questions and concerns; homework; and helping parents see the math in their children's work. In the second section teachers, administrators, and parent leaders share insights into establishing effective home-school relationships. Forthcoming from Scott Foresman in winter 2002. For information, contact [Investigations\\_Implementation@terc.edu](mailto:Investigations_Implementation@terc.edu).

## Leveraging Learning Science Units

Pre-publication versions of the Leveraging Learning science units for grades 2–5 and 5–8 are available for use during the 2001–2002 school year. The Leveraging Learning units cover topics such as acid rain, groundwater, solar energy, the human digestive and circulatory systems, and pets. Students conduct hands-on experiments; share data and exchange letters with other students; and participate in web-based activities that use reading, writing, and communicating to help students gain an in-depth understanding of the topics that are the focus of the units. Access them online at [LL.terc.edu](http://LL.terc.edu) or email [judy\\_vesel@terc.edu](mailto:judy_vesel@terc.edu).

As we went to press, TERC and publishing company It's About Time announced an agreement to publish TERC's new interdisciplinary high school curriculum, *Astrobiology: The Search for Life*. This innovative curriculum explores diverse concepts in chemistry, biology, physics, and Earth and space science as students examine the conditions necessary to sustain life on other worlds. Students develop research skills through modeling, lab experiments, field observations, and analysis of images and data from NASA's planetary space missions. Available in 2003.

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# Get Involved

## Online Science-athon

Participate in the Online Science-athon! The Science-athon offers students in grades 2–8 opportunities to discover science in their daily lives through three online challenges. Challenges include: Marble Roll (force and motion), How Tall Am I? (heredity), and Catching Sunshine (solar energy). Each challenge involves 10–12 hours of class time, data submission to a central database, and includes the exploration of questions using student-generated data. Visit [scithon.terc.edu](http://scithon.terc.edu) or contact [judy\\_vesel@terc.edu](mailto:judy_vesel@terc.edu).

## TERC Fellows Program

TERC is pleased to announce a Fellows Program for teachers in the Arlington, Cambridge, and Somerville, Massachusetts, public schools. The Center for Education Partnerships (CEP) at TERC is sponsoring the program. CEP is looking for teachers of grades 5–8 with a strong interest in science education who might like to work with TERC over the course of the next several years. Fellows will be involved in conceptualizing, designing, and building the Fellows Program; helping to develop new school science materials for grades 5–8; attending TERC informal presentations, workshops, and seminars as their time permits; and accessing TERC resources. Teachers

will receive a stipend. Contact Tara Robillard at [tara\\_robillard@terc.edu](mailto:tara_robillard@terc.edu) or 617-547-0430.

## Massachusetts Earth Science Alliance

The Center for Earth and Space Science Education (CESSE) at TERC, in partnership with Massachusetts Earth science teachers, has established the Massachusetts Earth Science Alliance (MESA), a consortium working to promote state-wide improvement of K–12 Earth science education in public and private schools. Members include Earth and space science teachers, scientists, school districts, state and federal agencies, educational developers and publishers, science museums, institutions for the training and professional development of teachers, and the business community. New members are welcome! Learn more at [mesa.terc.edu](http://mesa.terc.edu).

## Try Science

Register for Try Science, an online, graduate level course designed by TERC and Lesley University for K–8 educators who would like to strengthen their science background, learn more about inquiry-based science, and align their classrooms with the National Science Education Standards.

**Online Spring Semester**—Monday, January 28–Friday, May 3, 2002

**Online Summer Semester**—Monday, May 20–Friday, August 16, 2002  
Try Science, 3 graduate credits

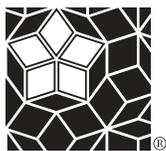
Try Science is the first course in an online science education master's degree program at Lesley University. Contact Doreen Stuart at (617) 349-8938 or [science@mail.lesley.edu](mailto:science@mail.lesley.edu).

The following program courses will also be offered in spring 2002 for students who have completed Try Science:

Investigating Physics  
Biological Explorations  
Earth Science from a New Perspective

## NSIP

The NASA Student Involvement Program (NSIP) is NASA's national K–12 competition. NSIP is a rewarding experience that promotes learning and honors excellence. The competitions are an exciting way to bring science, math, technology, and geography standards into your classroom. For 2001, NSIP has extended two of its competitions to K–2 students and opened most competitions to individual students as well as to teams. Aerospace Technology Engineering Challenge, NSIP's newest competition, asks students to design, build, and test spacecraft structure by using the same process as NASA aerospace engineers. Visit [education.nasa.gov/nsip](http://education.nasa.gov/nsip).



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