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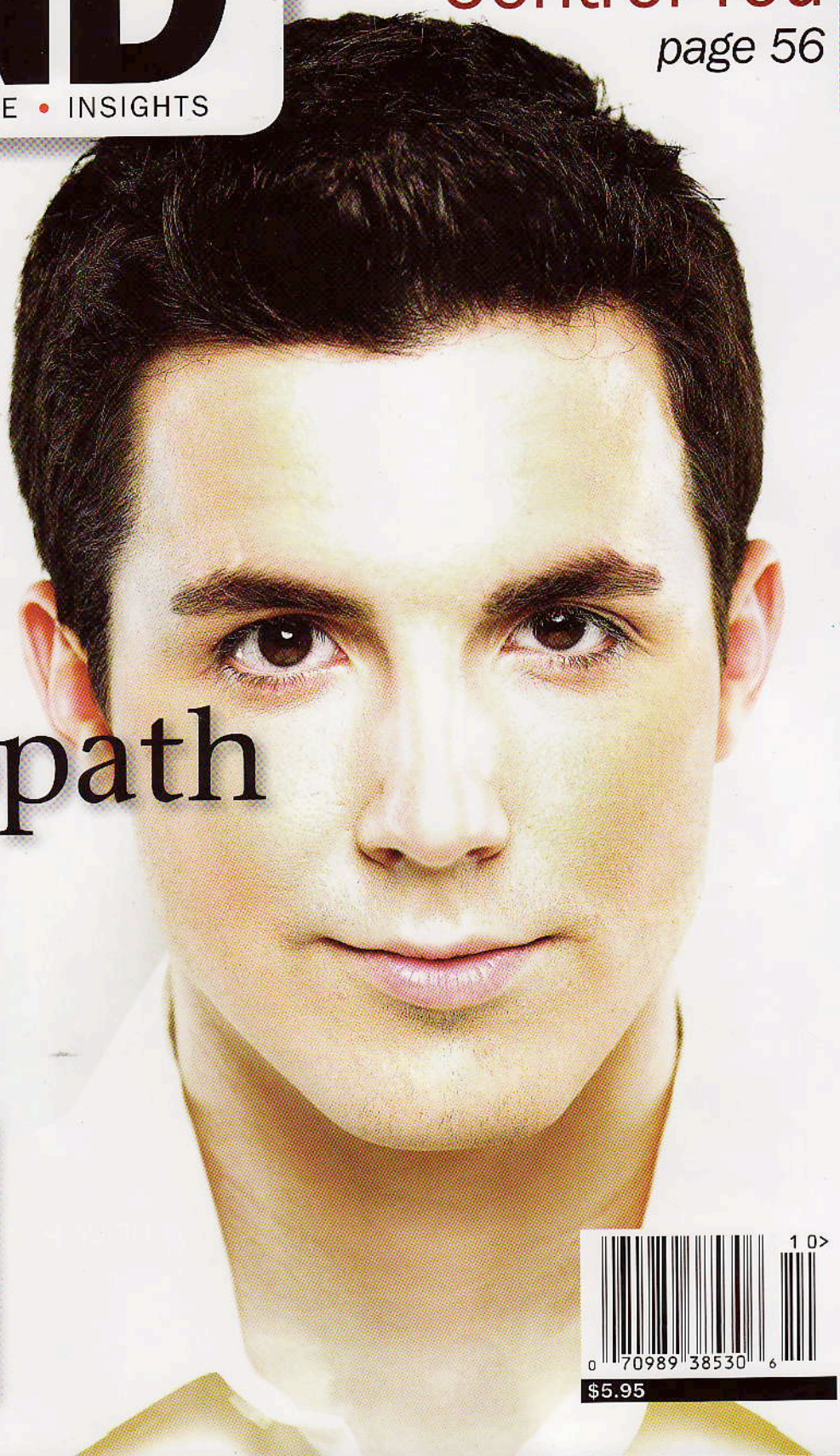

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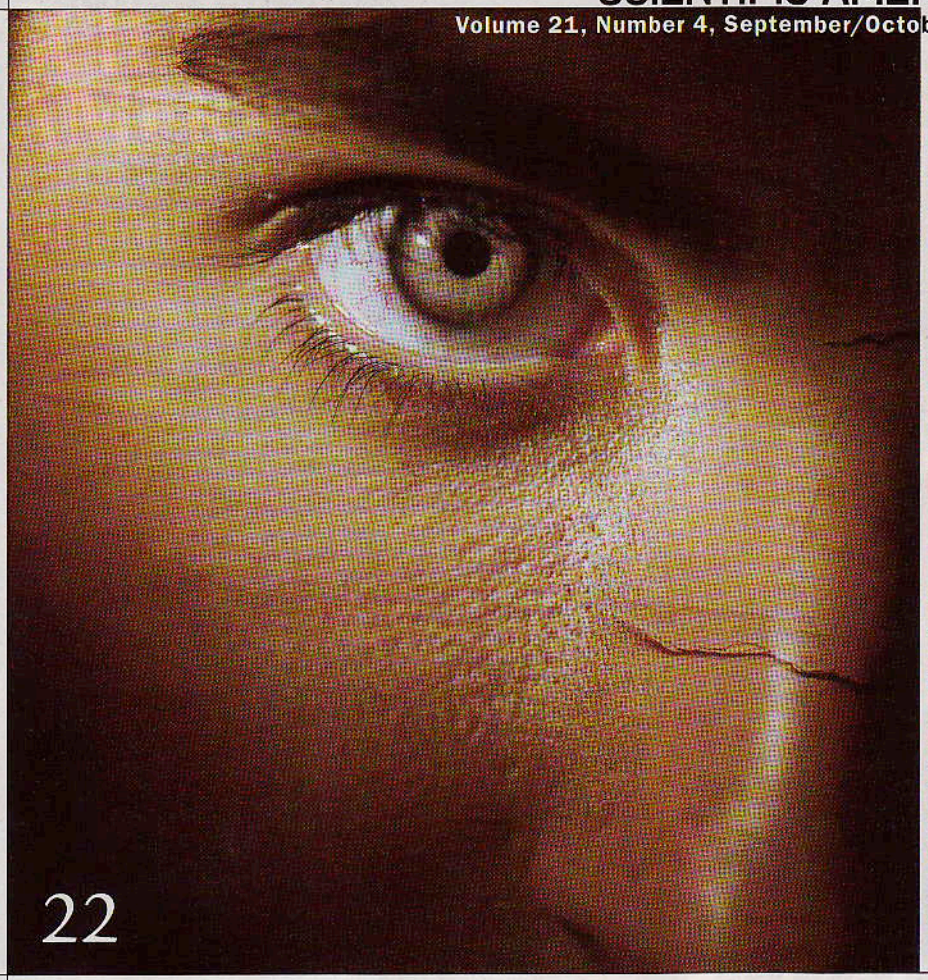

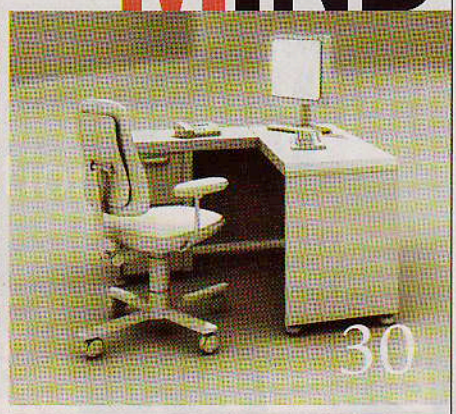

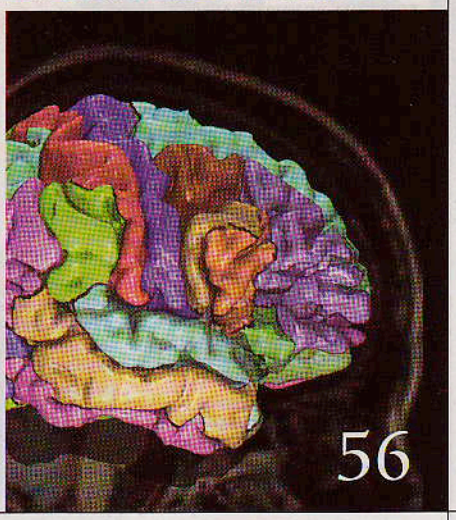

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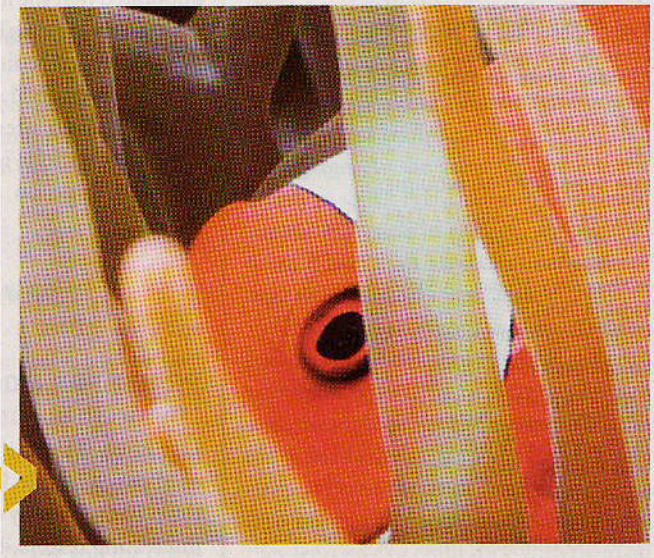

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SPECIAL REPORT

Physical Education

There has been a lot of talk about what is broken in the U.S. education system and why American students lag behind Europeans and Asians. But in this back-to-school special section we highlight solutions: elegant research suggesting simple—and surprising—ways to nurture academic achievement.

The theme of these three articles: Actions shape thoughts. It turns out that touch, movement and gestures are critical to learning. And why not? From our beginnings as toe-nibbling infants, we experience the world through our bodies as well as our brains, and the more integration between the two, the better.

Children who construct sophisticated block towers in preschool go on to score higher on high school math tests [see "The World at Our Fingertips," at right]. And contrary to reigning stereotypes, physically fit youngsters are more likely than their nerdly counterparts to get good grades [see "Smart Jocks," page 42]. Meanwhile gesticulating, too, aids intellectual and problem-solving abilities [see "Hands in the Air," page 48].

Enough said. For your own take on how doing promotes learning, start turning these pages.

ZIGY KALUZNY Getty Images

The WORLD at Our Fingertips

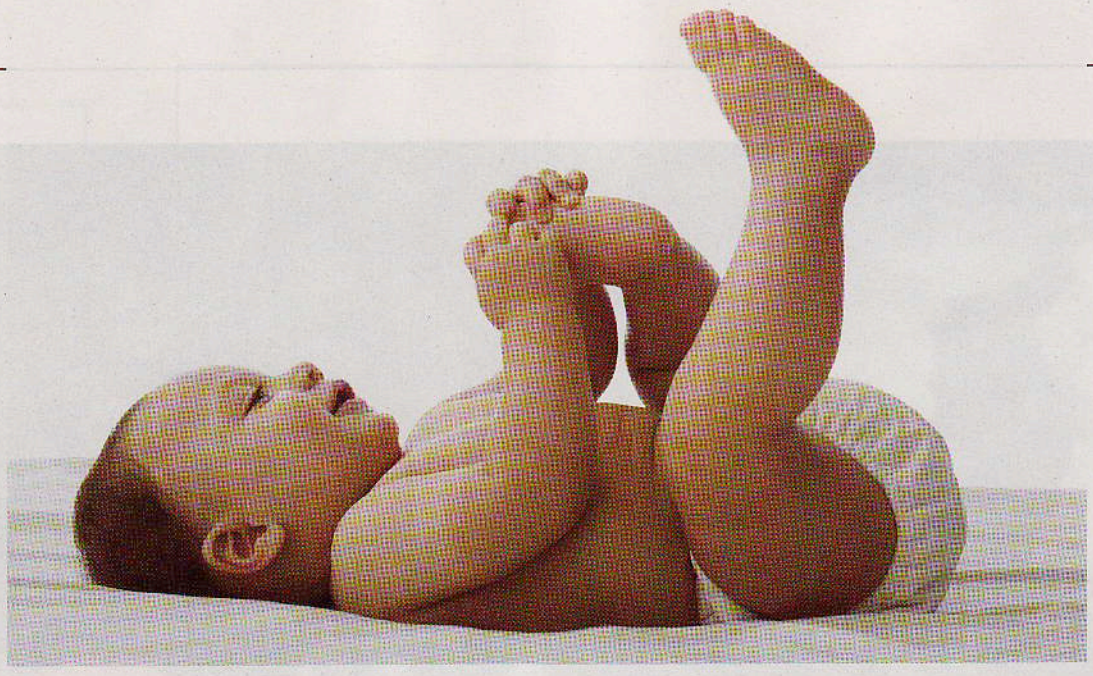
The sense of touch helps children to ground abstract ideas in concrete experiences

By Derek Cabrera and Laura Colosi

One evening while one of us (Colosi) was making dinner, her six-year-old daughter, Gianna, appeared with 10 little pieces of paper in her hand. She had been doing her homework, she said, and each of the scraps contained one of the words she was supposed to learn. When her mother asked why Gianna had torn apart her spelling list, she shrugged: "So I can do stuff with it." For Gianna, abstract concepts became easier to understand after she had transformed them into physical objects—in this case, pieces of paper she could hold, feel and manipulate.

The connection between touch and understanding is deeply instinctual, beginning in infancy and continuing, in varying forms, throughout our lives. Experiments have found that touch is as important as vision for learning and retaining information. Studies also show that tactile activities such as playing with blocks help children improve everything from their math abilities to their thinking skills. We are knowledge architects, building intellectual edifices through physical experiences.

Yet many school curricula are based on the old paradigm that



Long before a baby understands language, touch enables learning. When infants grab and knead their own limbs, they are trying to discover what is part of their own bodies and what is external.

knowledge flows from an expert instructor to a passive student. This mode of teaching is especially evident after children leave kindergarten for the long trek through elementary, middle and high school, where instruction relies less on hands-on exploration and more on rote memorization designed to improve test results. In contrast, haptics—the study of how the sense of touch affects the way people interact with the world—suggests that if educators engaged all of their students' senses, the children would not only learn better, they would think better, too.

The mind-expanding potential of haptic learning is not just for kids. LEGO, the Danish toy manufacturer, is marketing a training program called Serious Play to corporate clients. Teams of employees build LEGO models and use them to enact business scenarios—a corporate takeover, say—to spark new ideas and foster esprit de corps. The inspiration for LEGO's program, according to the company's Web site? Plato, who famously wrote: "You can discover more about a person in an hour of play than in a year of conversation." You may be able to learn more about the world, too.

FAST FACTS

To Touch Is to Think

1 » Learning through touch is instinctual. Even newborns can recognize objects by touch alone.

2 » At first, tactile learning involves manipulating objects. But as children mature, they begin to apply these physical concepts to abstract ideas.

3 » Hands-on exploration helps children learn more and remember what they have discovered. It also enhances math, verbal and thinking skills.

The Play Instinct

For children, play is second nature—no life coach required. It is, indeed, the child's way of being. Even the youngest infants experiment with touch and movement to figure out what belongs to them and what to their environment. Every parent has watched their wriggling baby test the body's limits, kicking legs, flapping arms and twisting appendages with gusto.

The notion that play has deeper value than diversion is not new [see "The Serious Need for Play," by Melinda Wenner; Scientific American Mind, February/March 2009]. As early as 1693, philosopher John Locke proposed helping children learn language through "dice and play-things, with the letters on them to teach children the alphabet by playing." In the 19th century German educator Friedrich Froebel argued that integrating play into educational settings would engage children and foster a long-term interest in learning, contradicting the belief, widely held at the time, that children younger than seven could not be taught because of their short attention spans. Froebel created blocks known as "Froebel gifts" to help students learn through hands-on play. He is considered the father of kindergarten.

In the 1960s Swiss developmental psychologist Jean Piaget posited that play is how children make sense of the world and acquire the skills they will need to negotiate adult life. Piaget found that in-

AGE FOTOSTOCK

Children who had played the most with blocks in preschool had **higher math scores** in seventh grade.

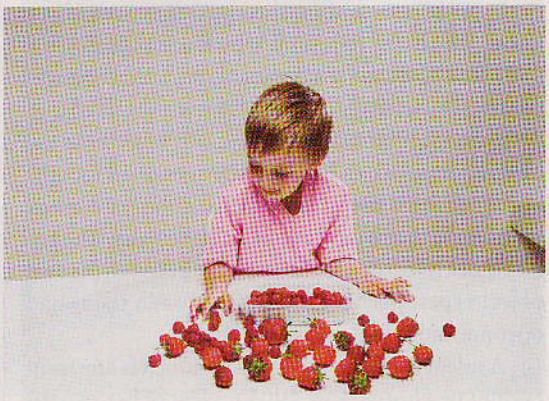
fants and children until the age of seven learn primarily through imitation, play and object manipulation; they first develop their reflexes and hand-eye coordination and experiment with spatial abilities, and later they use images and words to represent objects so they can classify them. Older children develop logic and reasoning skills by manipulating objects and sorting them—from smallest to largest, say—mastering such concepts as scale, quantity and length. As one Piaget acolyte, Massachusetts Institute of Technology professor Seymour Papert, put it, "Better learning will not come from finding better ways for the teacher to instruct, but from giving the learner better opportunities to construct."

Grasping the Curriculum

A myriad of so-called manipulatives (standardized versions of Gianna's little pieces of paper) fill preschool classrooms—wooden blocks, math beads, coins, letters made of sandpaper—and for good reason. Haptic feedback can help children retain information and hone their academic skills.

In 2006 science education professor M. Gail Jones of North Carolina State University and her colleagues had 36 middle and high school science students conduct nanoscale experiments on a simulated virus, measuring, pushing, cutting and poking the organism. One group of students could "feel" the virus through a haptic gaming joystick attached to their microscopes. The other group used a mouse instead of a joystick to move the organism under the microscope, receiving visual feedback only. After the lesson, the students filled out a questionnaire to measure their knowledge. The students who received haptic feedback recalled a greater number of viral characteristics and found the lesson more interesting.

Touching and manipulating objects also promotes the symbolic thinking essential to learning language and mathematics. In a 16-year longitudinal study published in 2001, educational theorist Charles H. Wolfgang of Florida State University followed 37 preschool children as they played with blocks. When the study began, Wolfgang and his team let the children, then four years old, play freely and encouraged them to use as many blocks as possible. Over the years Wolfgang followed the students' progress, tabulating their scores on the California Achievement Test in third, fifth and seventh grades, their enrollment in math classes and advanced courses, and their high school grade-point average. He then correlated the sophistication of each student's early block play with their test scores in middle and high school mathematics. The children who had played the most with blocks in preschool had significantly higher standardized math scores in seventh grade and high school than their peers did.



Toddlers quickly learn to distinguish balls from cubes and other shapes (*below*). That sorting ability grows more sophisticated with age (*left*) and forms the basis for making abstract distinctions—for example, among various shades of unethical behavior.

Based on the research he has conducted during the past 15 years, one of us (Cabrera) has concluded that hands-on exploration also contributes to four critical thinking skills essential to learning: making distinctions, recognizing relationships, organizing systems and taking multiple perspectives. At first, this learning involves objects—hence the importance of touch. But as children mature, they begin to apply these concepts—which they have quite literally grasped—to ideas.

This or That?

One of the critical lessons children glean from hands-on play is how to distinguish one object from another. Human beings are constantly called on to discriminate among words, locations, concepts, objects and life-forms with varying degrees of specificity. Indeed, this skill is critical: if children could not, for example, tell the difference between the many va-

(The Authors)

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ALEX SLOBODKIN iStockphoto (numbered blocks); BETSIE VAN DER MEER Corbis (child with berries); AGE FOTOSTOCK (shape sorter)

If children could not distinguish between berries, they would not know **food from poison.**

rieties of berries and mushrooms, they would not know which are food and which are poison. In a 1997 study psychologist Laura Namy, then at Northwestern University, and her colleagues observed that very young children classify and sort objects. In the experiments, babies between the ages of 16 months and 21 months played with balls, cubes and a box with a hole that would admit only the balls. The babies quickly learned to differentiate between the two object types, pushing the balls through the round opening and leaving the cubes aside.

A talent for discrimination by touch is apparent even in newborns. In a 2005 review of her experimental work with infants, psychologist Arlette Streri of Paris Descartes University reported that just 16 hours after birth, babies could recognize an object using touch alone, even when encountering it again at a different angle.

Tactile exploration enhances reasoning skills. When stacking coins, for example, children learn that two piles of equal value may look quite different from each other.

Researchers had the newborns handle several geometric shapes and measured how much time they spent exploring each one. The babies spent less time with objects they had touched before, suggesting that they already knew them and could recognize them from their contours. In other words, the infants could interpret an object's shape from multiple perspectives—a precursor of the adult ability to understand the world from the perspectives of different people. Even at an extremely young age and before the development of language, children can spontaneously discriminate among objects.

Touch helps older children sharpen these abilities when the time comes to draw more abstract distinctions—not only between, say, mammals and reptiles but between a horse and a zebra. In a 2006 study of prekindergarteners through third graders, psychologists Karyn Wellhousen and Rebecca Giles of the College of Education at the University of South Alabama observed that children who frequently played with blocks were more likely to participate in tasks involving the use of symbols such as letters and numbers. The block players also built larger vocabularies, which was evident when they described their structures to their playmates and teachers.

Connecting the Dots

Touch can also help children discern relationships, a critical skill in many areas of life. Italian physician and educator Maria Montessori, who observed that thinking is "expressed by the hands before it can be put into words," used many materials in her schools to demonstrate relationships of scale. One was the pink tower, in which children stack graduated pink wooden cubes into a tapering structure. As they handle and place the cubes, the children come to understand how the size of each piece relates to its position within the whole. Montessori schools also highlight the relationship between part and whole by giving students pie pieces to help them work with fractions. In every case, fitting the pieces together in the right way solves the problem.

Parents can improvise such lessons at home. Cabrera's son, Carter, was baffled by his early encounters with mathematics. So the two gathered a pile of Cheerios and sat down to play. It was a great help to Carter to count out three Os and hold them in his hand, then place them within a larger object (a small bowl) that represented the unit of three. Thus, he discovered the relationship between unity (a bowl containing three Cheerios) and quantity (three individual Cheerios): they have equal value, but they are not the same. That was no small achievement—this simple understanding serves as the basis of all algebra and the concept of variables.

As their knowledge of relationships grows, children come to see that the world consists not just of objects but of systems made up of parts. Early on, children learn that their bodies consist of a head, torso, legs and arms and that their heads, in turn, have eyes, ears, nose, mouth and brain. Over time they master increasingly complex systems, from the three atoms of a water molecule to an ecosystem composed of dirt, air, water, trees and animals.

Touch can help children organize systems as

KIM TAYLOR DK Images/Getty Images (berries); AGE FOTOSTOCK (counting coins)

well as understand them—the goal being to foster minds that can synthesize information as well as break it into its component parts. In a 2006 experiment led by elementary education professor James Minogue of North Carolina State University, middle school science students who received haptic feedback through a stylus as they designed a virtual animal cell—letting them feel shape, size, texture, viscosity, elasticity and resistance to motion as they arranged the cell's organelles—did a slightly better job at organizing their cell than did students who received no haptic feedback. But the positive effect was especially strong among students who did not know much about cell structure before the experiment.

Other People's Shoes

Once children understand how objects relate to one another, their imaginations are primed to consider the world from different perspectives—whether that means interpreting the Civil War from both the Northern and Southern standpoints or settling a playground quarrel. Learning to see things from various points of view is an important skill. It enhances the intellect by pushing us to challenge our assumptions and builds social skills by encouraging emotional intelligence, empathy and compassion.

Although perspective is a visual metaphor, it can be achieved through touch alone. In a 2010 study led by neuroscientist Ryo Kitada of Japan's National Institute of Physiological Sciences, researchers placed a plastic hand on a table in front of an adult volunteer—a right or a left hand, palm up or down, pointing in any direction. The volunteer then had to indicate as quickly as possible the side of the body to which the hand belonged by depressing a pedal with his or her left or right foot. In some cases, the subjects were asked to imagine the hand was their own, in others that it was the hand of someone seated opposite. Sometimes the volunteers could see the hand but not touch it, and in other trials they touched it blind. The response times were just as quick and accurate when the participants used touch alone to identify the hand as when they used only sight, even when they were meant to imagine the hand on another person's body.

For children, touch provides a visceral understanding of multiple perspectives. As the infant studies showed, sorting objects by size, color or shape is an early touch-based introduction to point of view. So is make-believe: when children use puppets, dolls or dress-up to create imagined scenarios, they learn to see the world from another vantage point. In research conducted in Austin in 1993, education specialist Stuart Reifel of the University of Texas and June Yeatman, a nursery school teacher, recorded four- and five-year-olds talking with one another as they played with various objects, toys and art supplies. After analyzing the conversations, Reifel concluded that children routinely take on different personas, switching frequently from one character to the next. This sort of fantasy role-playing, he believes, lets children try out new personalities, adopting the perspective of each in turn.

By helping children build mental constructs of the complex web of relationships among objects, ideas and people, the sense of touch prepares them to approach any problem—even the most challenging and sophisticated ones. Listen to Nobel Prize winner James D. Watson describe how he and Francis Crick discovered the structure of DNA. "In place of pencil and paper, the main working tools were molecular models superficially resembling the toys of preschool children," he said. "All we had to do was construct a set of models and begin to play." M

Fantasy play is a hands-on way to imagine what it feels like to be somebody, or something, else. Make-believe helps children develop tolerance and empathy and a respect for diverse points of view.

AGE FOTOSTOCK

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