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In times of diminishing financial resources, educators must make hard choices. Do dance, theater, and physical education belong in the budget? Are they frills or fundamentals? What exactly does brain research tell us about the relationship between the body and mind?

For years, it seemed that the educational and scientific communities believed that thinking was thinking and movement was movement, and never the twain would meet. Maverick scientists envisioned links between thinking and movement for decades -- but with little public support. Today, we know better. This chapter reveals the strong links between physical education, the arts, and learning.

Movement and Learning

If we want to address drug education, second languages, diversity education, multiple intelligences, improving reading scores, reducing dropouts, encouraging girls in math and science, thematic instruction, and AIDS education, that's great. But what will we eliminate to make time for those things? Anything deemed a frill is likely to go first. For some shortsighted officials, that means physical education. Recent brain research tells us that's a mistake.

Part of the reason for the outdated separation of mind and body comes from simple observation. If the brain is in the head and the body is below the head, how could there be any links? What would happen if the cerebellum, an area most commonly linked to movement, turned out to be a virtual switchboard of cognitive activity? The first evidence of a linkage between mind and body originated decades ago with Henrietta Leiner and Alan Leiner, two Stanford University neuroscientists. Their research began what would eventually redraw "the cognitive map" (S. Richardson 1996).

The Leiners' work centered on the cerebellum, and they made some critical discoveries that spurred years of fruitful research. First, the cerebellum takes up just one-tenth of the brain by volume. But it contains over half of all its neurons. It has some 40 million nerve fibers, 40 times more than even the highly complex optical tract. Those fibers not only feed information from the cortex to the cerebellum, but they feed them back to the cortex. If this was only for motor function, why are the connections so powerfully distributed in both directions to all areas of the brain? In other words, this subsector of the brain -- long known for its role in posture, coordination, balance, and movement -- may be our brain's sleeping giant.

In the past, the cerebellum was thought to merely process signals from the cerebrum and send them to the motor cortex. The mistake was in assuming the signals went only to the motor cortex. They don't (S. Richardson 1996, p 100). The last place information is processed in the cerebellum, before it is sent to the cortex, is the dentate nucleus. Though the dentate nucleus is missing in most mammals, it is largest in primates with the highest learning capabilities. A smaller area, the neodentate nucleus is present only in humans and may have a significant role in thinking. Neurologist Robert Dow of Portland, Oregon was one of the first to make the links. One of his patients had cerebellar damage and -- surprisingly -- impaired cognitive function (S. Richardson 1996, p. 102). Suddenly, linking movement and thinking became inescapable.

Just how important is movement to learning? Ask neurophysiologist Carla Hannaford and she'll spend all day telling you. She says the vestibular (inner ear) and cerebellar system (motor activity) is the first sensory system to mature. In this system, the inner ear's semicircular canals and the vestibular nuclei are an information gathering and feedback source for movements. Those impulses travel through nerve tracts back and forth from the cerebellum to the rest of the brain, including the visual system and the sensory cortex. The vestibular nuclei are closely modulated by the cerebellum and also activate the reticular activating system (RAS), near the top of the brain stem. This area is critical to our attentional system, since it regulates incoming sensory data. This interaction helps us keep our balance, turn thinking into actions, and coordinate moves. That's why there's value in playground games that stimulate inner ear motion like swinging, rolling, and jumping.

Peter Strick at the Veteran Affairs Medical Center of Syracuse, New York, made another link. His staff has traced a pathway from the cerebellum back to parts of the brain involved in memory, attention, and spatial perception. Amazingly, the part of the brain that processes movement is the same part of the brain that's processing learning.

Here's another example. Neuroscientist Eric Courchesne of the University of California at San Diego says autism may be related to cerebellar deficits (L. Richardson 1996). His brain-imaging studies have shown that autistic children have smaller cerebellums and fewer cerebellar neurons. He also has linked cerebellar deficits with impaired ability to shift attention quickly from one task to another. He says the cerebellum filters and integrates floods of incoming data in a sophisticated way that allow for complex decision making. Once again, the part of the brain known to control movement is involved in

learning. Surprisingly, there is no single "movement center" in our brain (Greenfield 1995). Movement and learning have constant interplay.

In Philadelphia, Glen Doman has had spectacular success with autistic and brain-damaged children by using intense sensor integration therapy. Over the years, many teachers who integrated productive "play" into their curriculum found that learning came easier to students.

At the 1995 Annual Society of Neuroscience Conference, W.T. Thatch Jr. chaired one of the most well-attended symposiums: "What is the Specific Role of the Cerebellum in Cognition?" He's a researcher at the Washington University School of Medicine who's been pulling together data for years. The 800 attendees listened carefully as the panel made a collective assault on a neuroscience community blinded by years of prejudice. Nearly 80 studies were mentioned that suggest strong links between the cerebellum and memory, spatial perception, language, attention, emotion, nonverbal cues, and even decision making. These findings strongly implicate the value of physical education, movement, and games in boosting cognition.

Motor Development and Learning

There is, in fact, substantial biological, clinical, and classroom research that supports this conclusion. The area known as the anterior cingulate is particularly active when novel movements or new combinations are initiated. This particular area seems to tie some movements to learning. Prescott's early studies (1977) indicate that if our movements are impaired, the cerebellum and its connections to other areas of the brain are compromised. He says the cerebellum also is involved in "complex emotional behavior" (emotional intelligence). His rat experiments bear out his conclusions. Rats with cerebellar deficits did worse on maze testing.

Our brain creates movements by sending a deluge of nerve impulses to either the muscles or the larynx. Because each muscle has to get the message at a slightly different time, it's a bit like a well-timed explosion created by a special effects team. This amazing brain-body sequence is often referred to as a spatiotemporal (space-time) pattern. Researcher William Calvin calls it a cerebral code. While simple movements like gum chewing are controlled by basic brain circuits nearest the spinal cord, complex movement -- like dance steps, throwing a ball, or doing a science experiment -- is quite different. Some simple movements like those with sequences, are controlled at the subcortical levels, like the basic ganglia and cerebellum. But novel movements shift focus in the brain because it has no memories to rely on for execution. Suddenly, we engage the prefrontal cortex and the rear two-thirds of the frontal lobes, particularly the dorsolateral frontal lobes. This is an area of the brain often used for problem solving, planning, and sequencing new things to learn and do (Calvin 1996).

Many researchers (Houston 1982, Ayers 1972, Hannaford 1995) verify that sensory motor integration is fundamental to school readiness. In a study done in Seattle, Washington, 3rd grade students studied language arts concepts through dance activities. Although the districtwide reading scores showed a decrease of 2 percent, the students involved in the dance activities boosted their reading scores by 13 percent in 6 months (Gilbert 1977). A complete routine included spinning, crawling, rolling, rocking, tumbling, pointing, and matching. Lyelle Palmer of Winona State University has documented significant gains in attention and reading from these stimulating activities (Palmer 1980). While many educators know of this connection, nearly as many dismiss the connection once children pass 1st or 2nd grade. Research suggests the relationship between movement and learning continues throughout life. The drama class at Garfield High School in Los Angeles gives students new hope for life skills success. The sensory-motor skills learned as children, through both play and orchestrated school activities, mean the proper neural pathways have been laid (Miller and Melamed 1989).

How critical is early movement? There may be a link between violence and lack of movement. Infants deprived of stimulation from touch and physical activities may not develop the movement-pleasure link in the brain. Fewer connections are made between the cerebellum and the brain's pleasure centers. Such a child may grow up unable to experience pleasure through usual channels of pleasurable activity. As a result, the need for intense states, one of which is violence, may develop (Kotulak 1996). With sufficient supply of the needed "drug" of movement, the child is fine. Deprive him or her of it, and you get problems.

Physical Education and Learning

As astonishingly high 64 percent of K-12 American students do not participate in a daily physical education program (Brink 1995). In William Greenough's experiments at the University of Illinois, rats who exercised in enriched environments had a greater number of connections among neurons than those who didn't. They also had more capillaries around the brain's neurons than the sedentary rats (Greenough and Anderson 1991). In the same way that exercise shapes up the muscles, heart, lungs, and bones, it also strengthens the basal ganglia, cerebellum, and corpus callosum, all key areas of the brain. We know exercise fuels the brain with oxygen, but it also feeds it neurotrophins (high-nutrient food) to enhance growth and greater connections between neurons. Aerobic conditioning also has been known to assist in memory (Brink 1995).

Researchers James Pollatschek and Frank Hagen says, "Children engaged in daily physical education show superior motor fitness, academic performance and attitude toward school as compared to their counterparts who do not participate in daily physical education" (1996, p. 2). Aerobic and other forms of "toughening exercises" can have enduring mental benefits. The secret is that physical exercise alone appears to train a quick adrenaline-noradrenaline response and rapid recovery. In other words, by working out your body, you'll better prepare your brain to respond to challenges rapidly. Moderate amounts of exercise, 3 times a week, 20 minutes a day, can have very beneficial effects.

Neuroscientists at the University of California at Irvine discovered that exercise triggers the release of BDNF, a brain-derived neurotrophic factor (Kinoshita 1997). This natural substance enhances cognition by boosting the ability of neurons to communicate with one another. At Scripps College in Claremont, California, 124 subjects were divided equally into exercisers and nonexercisers. Those who exercised 75 minutes a week demonstrated quicker reactions, thought better, and remembered more (Michaud and Wild 1991). Because studies suggest that exercise can reduce stress, there's a fringe benefit too. Chronic stress releases the chemicals that kill neurons in the critical area of the brain for long-term memory formation, the hippocampus. Brink (1995) says that physical exercise is still one of the best ways to stimulate the brain and learning (Kempermann, Kuhn, and Gage 1997).

There's other evidence for the potency of physical movement. We know that much of the brain is involved in complex movements and physical exercise -- it's not just "muscle work." In fact, depending on the type of workout, the part of the brain involved in almost all learning, the cerebellum, is in high gear (Middleton and Strick 1994). In a Canadian study with more than 500 schoolchildren, those who spent an extra hour each day in a gym class far outperformed at exam time those who didn't exercise (Hannaford 1995). Dustman's research (Michaud and Wild 1991) revealed that among three test groups the one that had the vigorous aerobic exercise improved short-term memory, reaction time, and creativity. All K-12 students need 30 minutes a day of physical movement to stimulate the brain, says the President's Council on Fitness and Sports. The Vanves and Blanshard projects in Canada revealed something even more dramatic. When physical education time was increased to one-third of the school day, academic scores went up (Martens 1982).

The Movement Arts

Three countries near the top in rankings of math and science scores (Japan, Hungary, and Netherlands) all have intensive music and art training built into their elementary curriculums. In Japan, every child is required to play a musical instrument

or be involved in choir, sculpture, and design. Teaching students art also has been linked to better visual thinking, problem solving, language, and creativity (Simmons 1995). Many studies suggest that students will boost academic learning from games and so called "play" activities (Silverman 1993). The case for doing something physical everyday is growing. Jenny Seham of the National Dance Institute (NDI) in New York City says she has observed for years the measurable and heartwarming academic and social results of schoolchildren who study dance. Seham bubbles with enthusiasm over positive changes in self-discipline, grades, and sense of purpose in life that her students demonstrate. She's now in the process of quantifying the results of over 1,500 kids who dance weekly at NDI.

Researchers know certain movements stimulate the inner ear. That helps physical balance, motor coordination, and stabilization of images on the retina. David Clarke at Ohio State University's College of Medicine has confirmed the positive results of a particular type of activity -- spinning (1980). With merry-go-rounds and swings disappearing from parks and playgrounds as fast as liability costs go up, there's a new worry: more learning disabilities. Clarke's studies suggest that certain spinning activities led to alertness, attention, and relaxation in the classroom. Students who tip back on two legs of their chairs in class often are stimulating their brain with a rocking, vestibular-activating motion. While it's an unsafe activity, it happens to be good for the brain. We ought to give students activities that let them move safely more often like role plays, skits, stretching, or even games like musical chairs.

Give a school daily dance, music, drama, and visual art instruction in which there is considerable movement, and you might get a miracle. In Aiken, South Carolina, Redcliffe Elementary test scores were among the lowest 25 percent in the district. After a strong arts curriculum was added, the school soared to the top 5 percent in 6 years (enough for the students to progress from 1st through 6th grade). This Title I rural school with a 42 percent minority student base showed that a strong arts curriculum is at the creative core of academic excellence -- not more discipline, higher standards, or the three Rs (Kearney 1996).

Arthur Stone of the State University of New York at Stony Brook says having fun may be good for your health. It decreases stress and improves the functioning of the immune system for three days after the fun. Most kids enjoy dance, arts, and games. It's not just good for the brain, it feels good, too. through primate experiments, neurophysiologists James Prescott and Robert Heath found that there's a direct link from the cerebellum to the pleasure centers in the emotional system (Hooper and Teresi 1986). Kids who enjoy playground games do so for a good reason: Sensory-motor experiences feed directly into their brains' pleasure centers. This is not of trivial importance; enjoying school keeps students coming back year after year.

Practical Solutions

Today's brain, mind, and body research establishes significant links between movement and learning. Educators ought to be purposeful about integrating movement activities into everyday learning. This includes much more than hands-on activities. It means daily stretching, walks, dance, theater, drama, seat-changing, energizers, and physical education. The whole notion of using only logical thinking in a mathematics class flies in the face of current brain research. Brain-compatible learning means that educators should weave math, movement, geography, social skills, role play, science, and physical education together. In fact, Larry Abraham in the Department of Kinesiology at the University of Texas at Austin says, "Classroom teachers should have kids move for the same reason that P.E. teachers have had kids count" (1997). Physical education, movement, drama, and the arts can all be one continual theme. Don't wait for a special event. Here are examples of easy-to-use strategies.

Goal Setting on the Move

Start class with an activity where everyone pairs up. Students can charade or mime their goals to a partner or go for a short

walk while setting goals. Ask them to answer three focusing questions such as:

- What are my goals for today and this year?
- What do I need to do today and this week in this class to reach my goals?
- Why is it important for me to reach my goals today?

You can invent any questions you want to ask students to create some, too.

Drama, Theater, and Role Playing

Get your class used to daily or at least weekly role plays. Have students do charades to review main ideas. Students can organize extemporaneous pantomime to dramatize a key point. Do one-minute commercials adapted from television to advertise upcoming content or review past content.

Energizers

Use the body to measure things around the room and report the results. For example, "This cabinet is 99 knuckles long." Play a Simon-Says game with content built into the game: "Simon says point to the South. Simon says point to five different sources of information in this room." Do team jigsaw processes with huge, poster-sized mind-maps. Get up and touch, around the room, seven colors in order on seven different objects. Teach a move-around system using memory cue words. For example, "Stand in the room where we first learned about . . ."

Ball toss games can be used for review, vocabulary building, storytelling, or self-disclosure. Students can rewrite lyrics to familiar songs in pairs or on a team. The new words to the song are content review; then they perform the song with choreography.

Get physical in other ways, too. Play a tug-of-war game where everyone chooses a partner and a topic from a list that all have been learning. Each person forms an opinion about the topic. The goal is for each student to convince a partner in 30 seconds why his or her topic is more important. After the verbal debate, the pairs form two teams for a giant tug-of-war for a physical challenge. All partners are on opposite sides.

Cross-laterals

Learn and use arm and leg crossover activities that can force both brain hemispheres to "talk" to each other better. "Pat you head and rub your belly" is an example of a crossover. Other examples include marching in place while patting opposite knees, patting yourself on the opposite shoulder, and touching opposite elbows or heels. Several books highlight these activities, including "Brain Gym by Paul Dennison and Smart Moves and the Dominance Factor by Carla Hannaford.

Stretching

To open class, or anytime that you need some more oxygen, get everyone up to do some slow stretching. Ask students to lead the group as a whole or let teams do their own stretching. Allow learners more mobility in the classroom during specif

times. Offer them errands, make a jump rope available, or simply let them walk around the back of the class as long as they do not disturb other students.

In general, you need to do all that you can to support physical education, the arts, and movement activities in your classroom. Make it a point to stand up for these activities in your school and district, too.

We are in a time when many children don't participate in physical education. Budget cuts often target the arts and physical education as "frills." that's a shame because there's good evidence that these activities make school interesting to many students and they can help boost academic performance. "Physical activity is essential in promoting normal growth of mental function," says Donald Kirkendall (Pollatschek and Hagen 1996, p. 2). Carla Hannaford says, "Arts and athletics are not frills. They constitute powerful ways of thinking, and skilled ways of communicating with the world. They deserve a greater, not lesser portion of school time and budgets" (1995, p. 88).

While it's counterproductive to make it more important than school itself, movement must become as honorable and important as so-called "book work." We need to better allocate our resources in ways that harness the hidden power of movement, activities and sports. Norman Weinberger, a scientist in the Department of the Neurobiology of Learning and Memory at the University of California at Irvine, says, "Arts education facilitates language development, enhances creativity, boosts reading readiness, helps social development, general intellectual achievement, and fosters positive attitudes towards school" (1995, p. 6). This attitude has become more and more prevalent among scientists who study the brain. It's time for educators to catch on.

The Motor Brain

Most educators know the value of "crawl time" in developing learning readiness. Yet many of today's children don't get the early motor stimulation needed for basic, much less optimal, school success. Today's infant is "baby-sat" by television, seated in a walker, or strapped in a car seat for hundreds of precious motor development hours. In 1960, the average 2-year-old spent an estimated 200 hours in a car. Today's 2-year-old has spent an estimated 500 hours in a car seat!

While infant safety is vital, few parents ever compensate for the confined, strapped-in hours. Considering the tomes of evidence on the impact of early motor stimulation on reading, writing, and attentional skills (Ayers 1972, 1991; Hannaford 1995), it's no wonder many children have reading problems. Although research on the general value of motor skills first surfaced many years ago, only today do we know about the specific value in reading, stress response, writing, attention, memory, and sensory development. As an example, the inner ear's vestibular area plays a key role in school readiness. Restak (1979) says, "Infants who were given periodic vestibular stimulation by rocking gain weight faster, develop vision and hearing earlier." Many link the lack of vestibular stimulation to dozens of learning problems including dyslexia (Cleeland 1984). How important is the timing of motor development? Felton Earls of the Harvard Medical School says, "A kind of irreversibility sets in By age four, you have essentially designed a brain that is not going to change very much more" (Kotulak 1996, p.7). And while much learning happens after age four, much of the brain's infrastructure is not in place.

The benefit of early motor stimulation don't end in elementary school; there is tremendous value in novel motor stimulation throughout secondary school and the rest of our life (Brink 1995). schools ought to make a planned program of specific motor stimulation mandatory in K-1 grades, but they also should integrate physical activity across the curriculum. In sports

we expect learners to use their brains for counting, planning, figuring, and problem solving. Every athlete is highly engaged in cognitive functions. It makes sense that we'd expect students to use their bodies for kinesthetic learning in the academic classes (see fig. 4.3).

In fact, new physical skills can take up to six hours to solidify. Henry Holcomb of Johns Hopkins University asserts that other new learning contaminates the memory process. "We've shown that time itself is a very powerful component of learning," he adds (in Manning 1997). Out visual capacity, measured by bits per second and carried by the optical nerve, is in the tens of millions (Koch 1997). That's far too much to process consciously (Dudai 1997). In order to either proceed or figure it all out, a student must "go internal" and give up that "external" attention. We can't process it all consciously, so the brain continues to process information before and long after we are aware that we are doing it. As a result, many of our best ideas seem to pop out of the blue. As educators, we must allow for this creative time if we want new learning to occur. After completely new learning takes place, teachers should consider short divergent activities like a ball toss or a walk that builds communication skills.

Resources

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