Chapter 3
Children's Natural Ways of Educating Themselves Still Work: Even for the Three Rs

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We live in an era of education gone amok. Over the past several decades, children in the US have been subjected to ever-increasing amounts of schooling, in ever more rigid forms, aimed at improving scores on standardized tests. Even out of school, children are increasingly placed into adult-directed, school-like activities, driven partly by parents' beliefs that childhood is a time of résumé building, toward getting into a prestigious college, rather than a time of free play (see also Bjorklund & Beer, this volume; Toub et al., this volume). Over the same decades that children's freedom to play and explore has been declining, researchers have documented dramatic increases in anxiety and depression, and decreases in internal locus of control and creativity among young people (Gray, 2011a; Kim, 2011; Newsom, Archer, Trumbetta, & Gottesman, 2003; Twenge et al., 2010; Twenge, Zhang, & Im, 2004). Elsewhere, I have given reasons for believing that the decline of children's freedom is a cause of these deleterious changes in their mental well-being (Gray, 2011a; Gray, 2013).

The mania for increased instruction, with consequent decreases in play, has even struck our kindergartens and preschools. Teachers in these settings are increasingly required to forego playful, creative, and enjoyable activities, so they can spend more time on worksheets and test preparation (Lynch, 2015). This is despite repeated studies showing that the immediate academic gains of such training wash out within 2 or 3 years (Carlsson-Paige, Almon, & McLaughlin, 2015; Darling-Hammond & Snyder, 1992; Katz, 2015). Indeed, in some well-controlled studies, students from academic-based preschools and kindergartens performed *worse*, by fourth grade and beyond, on measures of reading, math, social maturity, and emotional control than otherwise comparable children from play-based preschools and kindergartens (Goldbeck, 2001; Marcon, 2002; Schweinhart & Weikart, 1997).

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D.C. Geary, D.B. Berch (eds.), *Evolutionary Perspectives on Child Development and Education*, Evolutionary Psychology, DOI 10.1007/978-3-319-29986-0_3

The dominant assumption of education policy makers is that increased academic instruction is necessary for success in our culture. It may not be pleasant, but, like bad-tasting medicine, it is a necessary means to overcome a malady, in this case the malady of ignorance. There seems also to be the assumption that, for this medicine, more is always better. If a certain amount of instruction doesn't produce the results we want, then the solution must be to provide more of it. Blindly we continue on this track, with little thought about possible harmful effects of overdose.

The Origin of Modern Schools

In truth, schools as we know them have never been very effective in promoting what most liberal-minded people today would like to think of as education. Schools are not products of scientific knowledge about how children become educated. They are products of history. They arose to serve religious and political ends that are incompatible with ends that many enlightened thinkers today view as the ideal goals of education.

If a chief architect of our system of schooling were to be named, it would be August Hermann Francke, the Pietist leader who established the world's first large-scale system of compulsory schooling, in Prussia, beginning in the seventeenth century (Melton, 1988). He established the type of classroom in which children sit in rows, all supposed to be learning the same things, in the same way, at the same time, directed by the schoolmaster. He developed a standardized curriculum (consisting then mostly of religious catechisms) and a method of training and certifying teachers to teach that curriculum. He arranged to have hourglasses installed in classrooms, so everyone would follow the same pre-determined schedule, dictated by time.

Francke was very clear in his writings about the purposes of his schools. Reading was taught, so children would be able to read the Bible. Religious doctrine was taught in a manner that prevented any questioning of it. But the larger, clearly stated purpose was to break children's wills and make them obedient—obedient to schoolmasters, parents, lords, and ultimately God. In his instructions to schoolmasters, Francke wrote, "Above all, it is necessary to break the natural willfulness of the child. While the schoolmaster who seeks to make the child more learned is to be commended for cultivating the child's understanding, he has not done enough. He has forgotten his most important task, namely that of making the will obedient." (Melton, 1988, p. 43). He believed that the most effective way to break children's wills was through constant monitoring and supervision. He wrote, "Youth do not know how to regulate their lives, and are naturally inclined toward idle and sinful behavior when left to their own devices. For this reason, it is a rule in this institution that a pupil never be allowed out of the presence of a supervisor. The supervisor's presence will stifle the pupil's inclination to sinful behavior, and slowly weaken his willfulness." (Melton, 1988, pp. 43–44.)

Francke's methods were transported throughout Europe and to the colonies in America. Ultimately, as religious influence waned and the power of states increased,

the schools were taken over by states and curricula were altered to serve secular ends, but the methods were largely unchanged. Today, many educators wish that schools would promote curiosity, creativity, critical thinking, self-direction, and love of learning. But because our schools are essentially still the same as those designed by Francke, they are structurally incapable of such ends. Those ends all involve respecting children's wills. The method of requiring all children to attend to the same lessons, all at the same time, necessarily requires the suppression of, if not the breaking of, children's wills.

In times past, schools were never very successful at breaking wills, despite their best efforts, because school was only a small part of children's lives. Most of life was outside of school, where children were not always under adult surveillance. That was true even when I was a child, in the 1950s. Today, however, school is a huge part of children's lives, and even out of school many children are regularly in settings where adults monitor and govern their behavior. Counting homework, school today is for many the equivalent of what for an adult would be a full-time job—a very unpleasant sedentary full-time job, with a micromanaging boss, where one's work is constantly evaluated and compared with that of co-workers, where talking with co-workers is largely forbidden, and where permission is needed to leave one's workstation even to go to the bathroom. Research on employment satisfaction indicates that this would be an extreme example of the kind of job that most adults would rate as highly unpleasant and stressful (Galinsky, Bond, & Friedman, 1993). The well-documented recent increases among young people in depression and anxiety, and decreases in creativity and internal locus of control, may, indeed, reflect the successful breaking of wills.

A Biological View of Education

It is common today to equate education with schooling. But, for a meaningful discussion of education from a biological perspective, we must distinguish between the two. *Schooling* is the deliberate use of special procedures to teach a specific, preselected set of skills, concepts, beliefs, lore, and (or) values (a curriculum) to students. *Education,* in contrast, is the entire set of processes by which each new generation of human beings acquires any or all of the skills, concepts, beliefs, lore, and values—in short, the culture—of the previous generation. Education is cultural transmission. From a biological perspective, schooling is new, but education is as old as our genus. It is part of our biological makeup. While schooling takes place in special settings, under the direction of specially appointed teachers or masters, education takes place during every waking hour of every person's life, though it occurs most rapidly and significantly during childhood and adolescence (Lancy, this volume).

Beginning at least 2 million years ago, our ancestors began moving along an evolutionary track that made us ever more dependent on education. We developed means of hunting, gathering, processing foods, protecting ourselves from predators, birthing, caring for infants, navigating our environment, and combating diseases

that depended on accumulated knowledge, theories, and skills passed from generation to generation. We also came to depend on increasing levels of cooperation within and across groups, which required the cultural transmission of social mores, rules, rituals, stories, and shared beliefs and values that served to hold groups together and permit cooperation.

In any human group, children who failed to acquire crucial aspects of their culture would be at a serious disadvantage for survival and reproduction in adulthood. They would not know how to perform economically essential tasks, secure the cooperation of others, or attract a mate for reproduction. Natural selection, then, would strongly favor characteristics that promoted young people's desires and abilities to acquire the culture. Today, in the minds of most people, the onus for education lies with adults, who have the responsibility to make children acquire aspects of the culture, whether the children want to or not. But throughout history, the real onus for education has always been with children, and it still is today, despite our schools (see Geary & Berch, this volume; Sweller, this volume). Natural selection has ensured that children come into the world with instinctive drives to educate themselves—to learn what they must to become effective members of the society into which they are born.

Near the turn of the nineteenth to the twentieth century, about 40 years after Darwin's *Origin of Species*, the naturalist and philosopher Karl Groos wrote two books in which he developed a Darwinian theory of play. In the first, *The Play of Animals* (1898), he noted that play, superficially viewed, seems wasteful and maladaptive from an evolutionary perspective. It uses energy, for no immediate survival end. It is often noisy and can attract predators. It sometimes involves risky behaviors that can result in injury or even death. Play would surely have been selected out, by natural selection, if it didn't have significant compensatory advantages (see also, Bjorklund & Beers, this volume). On the basis of his own and others' observations, Groos proposed that play is the means by which animals practice and hone the skills that they must in order to survive to and through adulthood.

Groos's *practice theory of play* is widely accepted today by researchers who study play in nonhuman animals. It explains why young animals play more than do older ones (they have more to learn) and why animals that depend least on rigid instincts, and most on learning, play the most. It also explains differences among species in forms of play. One can predict, quite well, what animals will play at by knowing the chief constraints on their survival. For example, predatory animals play at chasing, or creeping and pouncing, while prey animals play at fleeing, dodging, and escaping.

In his second book, *The Play of Man* (1902), Groos extended his theory to humans. He pointed out that, consistent with his theory, humans, who have far more to learn than do other species, play far more, and over a longer duration of life, than do other species. He also pointed out a major difference between human play and that of other animals. Other animals play at species-specific skills—skills that characterize their way of life no matter where they live. Humans, too, play at species-specific skills (such as two-legged walking and talking), but also play at culture-specific skills—skills that may be unique to the culture in which they are

developing. He suggested that human children come into the world designed to attend to what people in their culture do and to incorporate those activities into their play. Groos referred to his theory as a theory of play, but I view it as more than that. It is a theory of education, or at least the foundation for such a theory.

Education in Hunter-Gatherer Bands

One way by which I have attempted to test and build on Groos's (1902) theory has been to examine children's play and education in hunter-gatherer cultures (see also Lancy, this volume). Until roughly 10,000 years ago, all humans were hunter-gatherers. The hunter-gatherer way of life is now almost completely extinguished, pushed out by modern influences. But as recently as the 1960s and 1970s, and to some degree even later, anthropologists could trek out into isolated parts of the world and find hunter-gatherers who were relatively unaffected by modern ways. Each culture that they found had its own unique characteristics—its own language, ways of hunting and gathering, stories, rituals, and art forms. Yet, in certain basic ways they were remarkably similar to one another, whether they were found in Africa, Asia, South America, or elsewhere, and whether in rainforests or deserts (Lee & Daly, 1999). To be clear, I should note that by "hunter gatherers," I am referring to groups that might more precisely be called *band* hunter-gatherers. I am not including the so-called *collector societies*, such as the Kwakiutl of the American northwest coast or the Ainu of Japan, which defended rich fishing grounds and were in many ways more similar to early agricultural societies than to band hunter-gatherers. In describing these cultures, I have chosen to use the past tense, to indicate that I am referring to practices that existed at the time they were studied, but may or may not exist today.

Wherever they were found, hunter-gatherers lived in bands of about 15–40 people, which moved from place to place within large but circumscribed areas to follow the available game and edible vegetation. Their most striking social characteristic, to Western eyes, was their extraordinary egalitarianism (Boehm, 1999; Gray, 2014; Ingold, 1999; Lee, 1988). They had no chiefs or big men, nor any obvious hierarchy of power. They made group decisions by consensus, often after long discussions. They shared food and material goods readily within the band and, less often, across bands. Part and parcel of their egalitarian ethos was an extraordinary degree of respect for individual autonomy. They didn't tell one another what to do, and, most remarkably, they applied this to children as well as adults.

I have never lived in or directly observed a hunter-gatherer society. My information comes from what others have observed and reported and from a survey that Jonathan Ogas (then my graduate student) and I conducted of ten anthropologists who, among them, had lived in seven different hunter-gatherer cultures—four in various parts of Africa, one in the Philippines, one in Malaysia, and one in New Guinea (Gray, 2009). In the survey, we asked each observer questions about the lives of children in the culture they observed. The literature review and survey led to three main conclusions concerning children's lives and education in such cultures.

The first conclusion is that hunter-gatherer children had to learn an enormous amount to become effective adults. The hunter-gatherer way of life was highly knowledge-intensive and skill-intensive. Moreover, because of the lack of occupational specialization, each child had to acquire nearly the whole culture, or at least that part of it appropriate to his or her gender. To become hunters, boys had to learn how to identify and track the many dozens of different species of mammals and birds that their group hunted. Liebenberg (1990) has presented a compelling argument that tracking by pre-agricultural hunters marked the origin of scientific reasoning. Hunters used scant marks in the sand, mud, or foliage as clues, which they combined with their accumulated knowledge from past experience, to develop and test hypotheses about the state of the animal they were tracking. As one anthropologist (Wannenburgh, 1979, p. 41) put it, "Everything is noticed, considered, and discussed. The kink in a trodden grass blade, the direction of the pull that broke a twig from a bush, the depth, size, shape, and disposition of the tracks themselves, all reveal information about the condition of the animal, the direction it is moving in, the rate of travel, and what its future movements are likely to be." They also had to develop great skill at crafting and using the tools of hunting, such as bows and arrows, blowguns and darts, or snares and nets, depending on the culture.

To become gatherers, girls—and boys also, to the degree that men also gathered—had to learn which of the countless varieties of roots, nuts, seeds, fruits, and greens were edible and nutritious; when and where to find them; how to extract the edible portions; and how to process them. These abilities included physical skills, honed by years of practice, as well as the capacity to remember, use, add to, and modify an enormous store of culturally shared verbal knowledge (Bock, 2005; Kaplan, Hill, Lancaster, & Hurtado, 2000). In addition, hunter-gatherer children had to learn to build huts, make fires, cook, fend off predators, predict weather changes, navigate their hunting and gathering grounds, treat wounds and diseases, assist births, care for infants, maintain harmony in the group, negotiate with neighboring groups, tell stories, make music, and engage in the various dances and rituals of their culture.

The second conclusion is that hunter-gatherer adults were extraordinarily nondirective and trusting in their relationships with children. The spirit of equality and autonomy characterized adult hunter-gatherers' interactions with children, just as it applied to their interactions with other adults. The central tenet of their parenting and educational philosophy seemed to be that children's instincts and judgments could be trusted, that children who were allowed to follow their own wills would learn what they needed to learn and would begin naturally to contribute to the band's economy when they had the skills and maturity to do so (see also Lancy, this volume). Illustrating this attitude, one set of researchers (Gosso, Otta, de Lima, Ribeiro, & Bussab, 2005, p. 218) wrote: "Hunter-gatherers do not give orders to their children; for example, no adult announces bedtime … Adults do not interfere with their children's lives. They never beat, scold, or behave aggressively with them, physically or verbally, nor do they offer praise or keep track of their development." Another (Hewlett, Fouts, Boyette, & Hewlett, 2011, p. 1173) wrote, "Foragers value autonomy and egalitarianism, so parents, older children or other adults are not likely to

think and feel that they know what is best or better for the child and are generally unlikely to initiate, direct, or intervene in a child's social learning."

The third conclusion is that hunter-gatherer children educated themselves through their self-directed exploration and play. Given hunter-gatherers' trustful approach to parenting, it is not surprising that children spent most of their time playing and exploring, without adult direction. To our question, "How much free time did children in the group you studied have for play?," all of the respondents to our survey said, essentially, that they were free to play all day or almost all day, every day, from the age of about 4, when they were weaned and began to move away from their mothers, on into their teenage years, when they began taking on some adult responsibilities (Gray, 2009). As one respondent (Karen Endicott, who studied the Batek) put it, "Children were free to play nearly all the time; no one expected children to do serious work until they were in their late teens." In a study of people with mixed hunter-gatherer and agricultural subsistence, in Botswana, Bock and Johnson (2004) found that the more a family was involved in hunting and gathering, and the less they were involved in agriculture, the more time children had to play.

In our survey, we also asked about the ways in which children played. The responses confirmed Groos's theory that children naturally incorporate culture-specific skills into their play. All of the respondents told us that the boys played endlessly at tracking and hunting. They would playfully follow animal tracks and track one another. With small bows and arrows, little children would shoot at such "game" as butterflies, toads, and small rodents. The two respondents who studied that Agta, a Philippine culture in which women as well as men hunt, said that girls as well as boys played at hunting in the groups they observed. Among the other play activities that the respondents listed were caring for infants, climbing trees, building vine ladders, building huts, using knives and other tools, making tools, carrying heavy loads, building rafts, making fires, defending against attacks from pretend predators, imitating animals (a means of identifying animals and learning their habits), making musical instruments, making music, dancing, and storytelling. The specific lists varied from culture to culture in ways that were consistent with variations in the adult activities (Gray, 2009). Several hunter-gatherer researchers have written that the children grew up in a play culture that paralleled and mimicked the larger culture within which it was embedded (Gosso et al., 2005; Shostak, 1981; Turnbull, 1961).

Although hunter-gatherer adults did not direct children's activities and rarely taught explicitly, they recognized that children learn by watching, listening, and participating, so they did not exclude children from adult activities. By all accounts, they were enormously tolerant of children's interruptions, and they allowed children into their workspaces even when that meant that the work would go slower. On their own initiatives, children often joined their mothers on gathering trips, where they learned by watching and sometimes helping. By their early teens, boys who were eager to do so were allowed to join men on big-game hunting expeditions, so they could watch and learn. By the time they were in their middle to late teens, they might be actively contributing to, rather than detracting from, the success of such trips. In camp, children often crowded around adults, and young ones climbed onto adults' laps, to

watch or "help" them cook, or make hunting weapons and other tools, or play musical instruments, and the adults rarely shooed them away (Draper, 1976).

Adults also helped children learn by responding to their requests. As one group of researchers (Hewlett et al., 2011, p. 1173) put it, "Sharing and giving are core forager values, so what an individual knows is open and available to everyone; if a child wants to learn something, others are obliged to share the knowledge or skill." An adult might show a child the best way to swing an axe, or point out the difference between the footprints of closely related animals. Usually such help came only when requested, but occasionally, especially when it could make a life-or-death difference, adults took the initiative in offering information, for example, about differences between edible and poisonous mushrooms (Hewlett et al., 2011).

Self-Education in Today's World: Democratic Schooling and Unschooling

Would the hunter-gatherer mode of education work in our society today? It's not hard to think of reasons why it might not. For starters, we have reading, writing, and arithmetic—skills that were foreign to hunter-gatherers, as they did not have written languages and their ways of life required little if any numerical calculations. One might plausibly argue, as Geary (2008) has, that the three Rs, and perhaps some of the scientific ways of thinking that we value today, are sufficiently different from the skills that hunter-gatherers had to acquire that children would not learn through their natural exploration and play, no matter how prevalent and valuable the skills are in the society in which they are developing (also Geary & Berch, this volume; Sinatra & Danielson, this volume; Sweller, this volume). Another obvious difference is that children in our society cannot observe, in their daily experiences, all of the ways that adults make a living. Our society is much more complex and less available to children than a hunter-gatherer society.

Without empirical evidence, claims that children's natural means of educating themselves would not suffice today are, of course, just speculation. It is equally easy to speculate in the opposite direction. Although hunter-gatherer cultures were no doubt more similar to one another than any of them are to ours, the basic kinds of skills needed for success in our culture may not be extraordinarily different from those in hunter-gatherer cultures. The written word is simply an alternative way of representing words, so learning to read and write might piggyback onto whatever evolved cognitive mechanisms we have for learning to understand and produce oral speech. Mathematics and science involve a variety of thinking that may not be fundamentally different from the thinking that hunter-gatherers engaged in regularly as they made and tested hypotheses about the movements of animals based on scant tracks, or the probable locations of tubers hidden underground during the dry season, or compass directions based on positions of stars. It also seems quite plausible that our innate learning mechanisms are far more adaptable and flexible than has been proposed by those evolutionary psychologists (e.g., Tooby & Cosmides, 1992) who

conceive of the human brain as a set of task-specific modules that came about to serve specific survival purposes.

The problem of how children become exposed to adult activities in our culture is, actually, not one that our compulsory school system has addressed. Children in school see what teachers do, but generally that's the only profession they witness first-hand. Children probably gain more of a sense of what adults in our culture do from watching television. Our children may be drawn to television partly for the same reason that hunter-gatherer children are drawn to adult activities in their culture. Children don't necessarily need to witness all professions first-hand, but it is useful for them to experience a good sample of the sorts of skills that are represented in the adult work world.

What would happen to children in our culture if we did not subject them to coercive schooling, but provided them with educational settings that are, for our time and place, the equivalent of a hunter-gatherer band? In other words, what if we provided them with a setting in which they are free to play and explore all day in their own chosen ways, where they can freely mix with other children over a broad range of ages, where they can witness and take part in a broad range of culturally valued activities, and where the adults are helpful but do not direct children's activities or evaluate their progress? Over many years, I've observed learning in just such a place—the Sudbury Valley School.

The school was founded in 1968, so it's been in operation now for almost half a century. It's a private day school, in Framingham, Massachusetts, open to students aged four through high-school age. It admits students without regard to any measures of academic performance and operates at a per-pupil cost about half that of the surrounding public schools. The school currently has approximately 160 students and eight adult staff members. It is housed in a large Victorian farmhouse and remodeled barn, on ten acres of land in a semi-rural area.

The school is, fundamentally, a democratic community. The founders' primary goal was to create a setting where children would experience the rights and responsibilities of democratic citizenship. In one-person-one-vote fashion, at weekly school meetings, the students and staff together create all of the school's rules, make decisions about school purchases, establish committees to oversee the school's day-to-day operation, and hire and fire staff members. All staff members are on 1-year contracts, which must be renewed each year through a process that involves a secret-ballot election. Those who survive this process and are reelected year after year are, necessarily, those who are admired by the students. They are people who are kind, ethical, competent, and who contribute significantly and positively to the school's environment. They are adults that the students may wish in some ways to emulate.

The school's rules are enforced by the Judicial Committee, which changes regularly in membership, but always includes one staff member and a set of students representing the full range of ages at the school. When a student or staff member is charged by another school member with violating one of the school's democratically made rules, the accuser and the accused must appear before the Judicial Committee, which judges innocence and guilt and, in the latter case, decides on an

appropriate sentence. The rules have to do with maintaining peace and order, protecting individuals' rights, and protecting the school, not with education.

The educational philosophy of the school is essentially the same as that of a hunter-gatherer band. The assumption is that if young people have ample opportunity to play, explore, and follow their own interests, in an environment rich in educational opportunities, they will learn what they must for success in their culture. The school gives no tests and does not in any way evaluate students' progress. There is no curriculum and no attempt by staff members to motivate learning. Courses occur only when a group of students take the initiative to organize one, and then the course lasts only as long as the students want it to last. Many students never join a course.

The staff members at the school do not consider themselves to be "teachers." They are, instead, the adult members of the community. They are the more mature and often more persuasive voices at school meetings, the people that students go to with problems that other students can't help them with, and the interface between the school and the larger community. Most of their "teaching," if one calls it that, is of the same variety as can be found in any human setting. It involves presenting ideas in the context of naturally occurring conversations and responding naturally to questions and requests for help. We might think of the staff at Sudbury Valley as in some ways the equivalent of the older and often wiser members of a hunter-gatherer band.

Except when they serve on the Judicial Committee, students are free all day, every day, to pursue their own interests. They are not divided into groups by the school nor assigned to specific spaces. They can interact with whom they please and go anywhere in the school buildings or grounds. The school has equipment for a wide variety of activities—including computers, a fully equipped kitchen, a woodworking shop, an art room, playground equipment, toys, games, and many books. Students also have access to a pond, a field, and a nearby forest for outdoor play and exploration. The most valuable educational resource at the school, for most students, is other students, who among them manifest an enormous range of interests and abilities.

Much of the students' exploration at the school, especially that of the older students, takes place through conversation. Students talk about everything imaginable, with each other and with staff members, and are thereby exposed to a huge range of ideas and arguments. Because nobody is an official authority, everything that is said and heard in conversation is understood as something to think about, not dogma to memorize or feed back on a test. Conversation, unlike memorizing material for a test, stimulates the intellect. Vygotsky (1962) argued, long ago, that conversation is the root of higher thought; and my observations of students at Sudbury Valley convince me that he was largely right. Thought is internalized conversation; actual conversations with other people get it started.

Many years ago, in collaboration with a part-time staff member at the school, I conducted a follow-up study of the school's graduates (Gray & Chanoff, 1986). The school was smaller then and had existed for only 15 years, but there were already 82 graduates who met our criteria—they had been students at the school for at least 2

years and had left at age 16 or older with no plans for further secondary schooling. We were able to locate 76 of these graduates, and 69 of them completed our rather extensive questionnaire—a response rate of 91 % of those who could be located, or 84 % of all the graduates. We found that those who had pursued higher education (about 75 % of the total) reported no particular difficulty getting into the schools of their choice and doing well there. Some, including a few who had never previously taken a formal course or an academic test (other than the SAT required for college admission), had gone on successfully to highly prestigious colleges and universities. As a group, regardless of whether or not they had pursued higher education, they were remarkably successful in finding employment that they enjoyed and earned them a living. They were pursuing a wide variety of occupations, including business, arts, science, medicine, other service professions, and skilled trades. Their success is perhaps especially remarkable, given that many of them came to the school because they were failing or doing poorly in the local public schools.

Many of the graduates had gone on successfully in careers that were direct extensions of passionate interests they had developed in play at the school. Here are a few examples: A woman who was captain of a cruise ship had played extensively with little boats on the school's pond as a young girl, and as a teenager had used the school's off-campus policy to apprentice herself to a ship caption on Cape Cod. A man who was a machinist and inventor had been "obsessed" with constructive play as a child. He would, among other things, make whole cities and factories from plasticine, with everything measured to scale. A woman who was a pattern maker in the high fashion industry had made doll clothes as a little girl and had then gone on, as a teenager, to making clothes for herself and her friends before apprenticing herself to a pattern maker. A man who became a mathematics professor had developed a strong interest in theoretical physics, and then math, as a teenager, from his passion for science fiction. Graduates who were successful artists, musicians, and computer specialists had all developed their interests and skills in free play at the school.

Most of the graduates said that a major benefit of their Sudbury Valley education was that they had acquired a sense of personal responsibility and self-control that served them well in all aspects of their lives. None said, in response to our question, that they regretted having gone to such an unusual school instead of a more traditional school. More recently, two larger studies of graduates, conducted by the school and published as books (Greenberg & Sadofsky, 1992; Greenberg, Sadofsky, & Lempka, 2005), resulted in similar conclusions. At least two dozen schools in the United States and roughly another dozen in other countries have been modeled after Sudbury Valley.

Another population of children and adolescents directing their own education in our society are those involved in the rapidly growing *unschooling* movement. These are young people who don't attend school at all. They are usually officially registered as homeschoolers, but are not subjected to any curriculum or tests at home because their parents subscribe to the philosophy that children learn best when they pursue their own interests in their own chosen ways. Gina Riley and I have conducted two survey studies of unschoolers. The first was a survey of 232 unschooling parents, which included questions about why they had chosen that educational route and

what role they played in their children's education (Gray & Riley, 2013). According to their own reports, most parents actively helped to connect their children with the broader community, so they could learn from sources outside of the family as well as inside. The second study was a survey of 75 adults who had been unschooled during what would have been their K-12 school years (Gray & Riley, 2015; Riley & Gray, 2015). Our findings were quite similar to the previous findings concerning Sudbury Valley graduates. The great majority had no regrets about having been unschooled. They believed that they were more self-directed, more responsible, and more motivated to continue learning than they would have been had they been schooled. Those who had gone on to higher education had no particular difficulties getting into colleges and universities or doing well there. They had gone on to a wide variety of careers, which in many cases were direct extensions of their childhood play.

Conditions that Optimize Children's Abilities to Educate Themselves: How Sudbury Valley Is Like a Hunter-Gatherer Band

Earlier, I suggested that Sudbury Valley is in some ways the educational equivalent, for our time and place, of a hunter-gatherer band. Here I will expand on that by describing six conditions, common to both settings, that appear to optimize children's abilities to educate themselves. These conditions also appear to characterize the environments of the most satisfied unschoolers (Gray & Riley, 2013, 2015). None of them are present in our standard schools.

The social expectation (and reality) that education is children's responsibility. When children know they are responsible for their own education, they assume that responsibility. We would not have survived as a species if that were not true. When we adults act as if we educate children, as we do in our conventional schools, we take that responsibility away from children. We convince them that their own curiosity and questions don't count, that play is trivial, and that their education depends on doing what they are told rather than their own initiative. Beliefs become self-fulfilling prophecies. Staff members at Sudbury Valley School and parents in unschooling families, like adults in hunter-gatherer cultures, do nothing to diminish children's natural assumptions that they are in charge of their own education.

Unlimited freedom to play, explore, and pursue one's own interests. To educate themselves, children need great amounts of free time—to make friends, explore, play, get bored, and overcome boredom. They need time for fleeting interests and to immerse themselves deeply in activities that engage their passions. They also need space—to roam, explore, get away, and experience the sense of independence and power that can only occur for children when no adult is watching.

Opportunity to play with the tools of the culture. Much of education has to do with learning to use the culture's tools. The way to master any tool fully is to play

with it, that is, to be creative with it, impose your will on it, and make it do what you want it to do. Hunter-gatherer adults recognize this, and so they allow even little children to play with the real tools of their culture, including those that could cause injury, such as fire, knives, and bows and arrows (Gray, 2009; Lancy, this volume). At Sudbury Valley, children play with the tools of our modern culture, including books, woodworking equipment, cooking utensils, and sporting equipment. Not surprisingly, the tool they play with most these days is the computer. Every child who looks around can see that the computer is by far the most valuable tool of our time, so it is no wonder that our children are drawn to computers as strongly as hunter-gatherer children are drawn to bows and arrows and digging sticks. They know in their bones that this is a tool they must master for success in the world in which they are growing.

Access to a variety of caring adults, who are helpers, not judges. In hunter-gatherer bands, the children's world is not segregated off from that of adults. Children see what adults do and incorporate that into their play. They also hear the adults' stories, discussions, and debates, and they learn from what they hear. When they need adult help, they can go to any of the adults in the band (Hewlett et al., 2011). At Sudbury Valley, too, adults and children mingle freely. There is no place in the school where staff members can go but students cannot. Students can listen to any adult discussions, observe whatever the adults are doing, and join if they wish. Students who need help can go to whichever staff member they think can best help them. Unschooling, too, appears to work best when children have regular access to multiple adults beyond just their own parents.

Adults can help best when they are not judges of the children, and adults in hunter-gatherer bands, the Sudbury Valley School, and unschooling families deliberately avoid the role of judge. None of us, regardless of age, can be fully honest with—fully willing to show our vulnerability to and ask for help from—people whose business it is to evaluate us. When we think we are being evaluated, we go into impression-management mode, in which we show off what we know and can do well and avoid what we don't know or can't do well. Evaluation also induces anxiety, which interferes with learning. Impression management and anxiety are antithetical to education, yet they are characteristics that our standard schools are well-designed to promote.

Free age mixing among children and adolescents. Hunter-gatherer children necessarily play in age-mixed groups, as there aren't enough children for age-segregated play (Konner, 1975). At Sudbury Valley, there are enough children that they could play just with others close in age, but they don't. By their own choices, they regularly play across large age ranges. In one quantitative study, we found that a quarter of all of the naturally occurring interactions among students involved students who spanned an age range of more than 4 years (Gray & Feldman, 1997). Daniel Greenberg, one of the founders of Sudbury Valley and the primary exponent of the school's philosophy, has long claimed that free age mixing is the secret to the school's educational success, and my research at the school tends strongly to confirm that view (Gray, 2011b; Gray & Feldman, 2004).

Vygotsky (1978) coined the term *zone of proximal development* to refer to the set of activities that a child cannot do alone or just with others of the same ability, but can do in collaboration with others who are more skilled. He suggested that children develop new skills and understanding largely by collaborating with others within their zones of proximal development. Extending that idea, Jerome Bruner and his colleagues (Sylva, Bruner, & Genova, 1976) introduced the term *scaffolding* as a metaphor for the means by which skilled participants enable novices to engage in a shared activity. The scaffolds consist of the reminders, hints, boosts, and other forms of help that elevate the child to a higher form of activity. In observational research at Sudbury Valley, Jay Feldman and I have documented many examples of such scaffolding (Gray & Feldman, 2004). We saw scaffolding in nearly all instances of play among children who differed considerably in age.

For example, we observed young children playing rather complicated board games and card games with older children. Generally, though there are exceptions, children under about age 9 can't play such games with age-mates. They lose track of rules, their attention wanders, and the game, if it ever gets started, quickly disintegrates. But we often observed children younger than that play such games with older children and adolescents. The older players reminded the younger ones what to do: "Hold your cards up." "Pay attention." "Try to remember what cards have been played." "Think ahead." Paying attention, remembering, and thinking ahead are the elements of intelligence. In keeping the younger players on task in order to keep the game going, the older players were, in effect, scaffolding the younger players' intelligence.

Age mixing benefits the older children as well as the younger ones, as it allows them to practice leading, guiding, and caring. We observed countless instances in which older children went out of their way to help much younger ones (Gray & Feldman, 2004). Teenagers seem to be drawn especially to the very youngest children. Evolutionarily, this makes sense, as they may be practicing for parenthood. We also observed many scenes in which older children explained concepts to younger ones, such as rules of games, rules of the school, or how to search for lost items. Explaining a concept to others is often the best way to stretch and consolidate one's own understanding of it. In an age-mixed environment, all children have the opportunity to learn through teaching.

Children learn from older and younger children even when they are not directly interacting with them. Younger children learn new words and concepts by overhearing the conversations of older ones, and they are inspired to try new activities by watching the older ones. At Sudbury Valley, young students become interested in such activities as reading, tree climbing, cooking, and playing musical instruments because they see older students enjoying these activities. Just as younger children are attracted to the more sophisticated activities of older ones, older children are attracted to the creative and imaginative activities of younger ones. At Sudbury Valley, we have frequently observed teenagers playing with paints, clay, or blocks, or playing make-believe games, often with younger children—activities that most teenagers elsewhere in our culture would have abandoned. Through such play, many become excellent artists, builders, storytellers, and creative thinkers.

Immersion in a stable, moral, democratic community. Hunter-gatherer bands and Sudbury Valley School are, in different ways, democracies. Hunter-gatherers made all group decisions through group discussion aimed at consensus. Whether or not children took part in those discussions, they witnessed them and knew they would play ever-greater roles in such decisions as they grew older. The children were treated with the same respect as the adults, so they grew up respecting others. Sudbury Valley is administered through a formal democratic process, involving discussions at the School Meeting, where each student and staff member has an equal vote. Unschooling families also tend to operate democratically, at least to the degree that they respect and take into account children's opinions and ideas in family decisions. In all of these settings, children are exposed, in everyday life, to the moral principles of the community in which they are immersed. In such an environment, children learn to be responsible not just for themselves but also for others and the community as a whole.

Learning to Read Without Formal Instruction

Assumptions of our standard school system are that learning to read is difficult, children won't learn it on their own, and, therefore, reading must be deliberately taught by professionals who know how to teach it. Indeed, familiarity with the slow, often painful process through which children commonly learn to read in school can lead one to see the origins of these assumptions. Vast amounts of research have gone toward trying to figure out the scientifically best way to teach reading, much of it centering on the debate, sometimes dubbed "the reading wars," between those who believe that most emphasis should be on phonics, right from the beginning, and those who favor a "whole language" approach, in which children start off reading for meaning, with phonics coming later. The debate is centuries old. Noah Webster, who created the first series of books designed to teach reading and spelling in secular schools, was an early warrior for phonics, while Horace Mann, the first secretary of education in any state in the union (Massachusetts), championed whole-language (Lemann, 1997). In recent decades, many controlled experiments have compared the two approaches, and the consensus of most reviewers is that phonics-first is the clear winner (Kim, 2008).

To me, it is no surprise that phonics-first would work better than whole-language in school classrooms. The classroom is all about training, which is the process of getting reluctant organisms to do or learn what the trainer wants them to do or learn. Under these conditions, a focus on the mechanical processes underlying reading, especially the conversion of sights to sounds, works better than attempts to promote reading through meaning, which require that students care about meaning, which require that they be able to follow their own interests, which is generally not possible in classrooms. The common classroom methods of direct instruction and drill can be applied to teaching phonics, but not to whole-language reading.

Experiments on reading are essentially always carried out in classrooms. Classrooms lend themselves to experiments. Researchers there have captive participants, who are used to doing what they are told and to taking tests on demand. It is easy to set up conditions in which students in some classes are taught in one way, those in others are taught in another way, and all are given the same test to see which method worked best. This is the kind of evidence supporting phonics-first instruction. In contrast, research on natural learning, outside of classrooms, requires non-experimental observational and survey methods, which tend to be scorned by hard-nosed researchers. It is useful to remember, however, that many of the greatest advances in science have come from multiple, converging observations. A prime example is Darwin's development of the concept of evolution by natural selection. In what follows I describe some systematic observations concerned with how children learn to read, on their own initiative, outside of classrooms.

Studies of Precocious Readers

Roughly one percent of US children, referred to as *precocious readers*, read fluently by age 4, before they have experienced any reading instruction in preschool, kindergarten, or first grade (Olson, Evans, & Keckler, 2006). Researchers have conducted systematic case studies of precocious readers, through interviews of parents, and have compared them with other children to see if they are unique in any other ways (Forester, 1977; Margrain, 2005; Olson et al., 2006). The results indicate that precocious reading does not depend on an unusually high IQ or any particular personality trait and is not consistently linked to socioeconomic class, but does depend on growing up in a setting where reading is a common and valued activity. Parents of precocious readers most often report that they or an older sibling often read to the child, but did not in any deliberate way attempt to teach reading. In the typical case, the parents at some point discovered, to their surprise, that their child was reading, at least in a preliminary way, and then they fostered that reading by providing appropriate reading materials and answering the child's questions about words. In essentially no cases did they provide anything like the systematic training in either phonics or word recognition that occurs in school.

In sum, precocious readers appear to be children who grow up in a literate home and, for some unknown reason, unlike even their siblings in the same home, develop an intense early interest in reading. Interest, not unusual brain development, is apparently what distinguishes them from others. Because of their strong motivation, they use whatever cues are available to figure out the meanings of printed words and sentences, and, along the way, with or without help, consciously or unconsciously, they infer the underlying phonetic code and use it to read new words. For them, reading for meaning always precedes phonics. In the words of one set of researchers (Olson et al., 2006, p. 215), "The precocious readers were not taught the prerequisite skills of reading such as phoneme-grapheme correspondence or letter-naming

skills but, instead, learned to read familiar, meaningful sight vocabulary; the rules of reading were not explicitly taught but apparently inferred over time."

The fact that even a small percentage of children learn to read by the age of four without formal instruction, and the evidence that most of these children are not unusually advanced in other respects, suggests that learning to reading may not be the extraordinarily difficult task that it appears to be in school. I can't resist a small anecdote here. I first became interested in precocious reading when my son began reading independently at age 3. One of the first signs of his reading occurred when we were visiting the town square of a New England village and he came over to me and said, "Why would men fight and die to save an onion?" The question confused me until I realized that he had just read the inscription on a Civil War monument and had pronounced the word "union" phonetically. My son's story fits well with the findings of research on precocious reading. He saw me spending much time reading, as I was a graduate student; his mother read to him frequently; and he often asked us to pronounce words that he saw on signs, cereal boxes, and such; but neither of us had tried to teach him reading. In particular, neither of us had explained the relationship between letters and sounds; he apparently figured that out on his own.

How Sudbury Valley Students and Unschoolers Learn to Read

Would children other than precocious readers learn to read without deliberate instruction, if they were immersed in a literary environment and were allowed to engage themselves with reading whenever they wished? At Sudbury Valley, there are no formal reading classes and no adult-imposed pressures to learn to read. Yet, according to long-time staff members, all of the students, in their own time, learn to read.

In my study of Sudbury Valley graduates, two of the respondents told me, independently, that they had come to the school as teenagers unable to read. Both had been passed along from grade to grade, in public school, with a diagnosis of dyslexia. Both told me that they learned to read within a few months after enrolling at Sudbury Valley. When I asked why they could learn there what they had been unable to learn before, they both told me, in effect, that for the first time in their lives nobody cared if they could read. The pressure was off. Now, in a relaxed way, they could concentrate on reading. They didn't have to hide behind a label. Both went on to college, with no designation of dyslexia or any other learning disability, and performed well there. Staff members at Sudbury Valley claim that they have never seen a case of real dyslexia at the school.

A few years after my study of Sudbury Valley graduates, two of my undergraduate students collected a set of 16 case histories of learning to read at Sudbury Valley. They identified students who had learned to read after enrolling at the school, and then they interviewed those students, the students' parents, and staff members to find out what they could about when each student learned to read, over what length of time the process took, why the student learned, and, to the degree that it was

known, how the student learned. More recently, I recruited a group of unschooling parents to address these same questions about their children's learning to read and thereby received 21 more case stories. My informal qualitative analysis of the total set of 37 cases led me to identify what I refer to as *seven principles of learning to read without formal instruction* (Gray, 2010b). Here they are.

There is no critical period for learning to read. For children in standard, graded schools, it is important to learn to read on time, to avoid being labeled as a failure and to move on from "learning to read" in the early grades to "reading to learn" in later grades. But the story is entirely different for Sudbury Valley students and unschoolers. The median age for learning to read (becoming a fluent reader) in the cases I examined was 7, but the range for most was from age 4 to 11, with one outlier not learning until age 14. There was no evidence that those who had learned earlier were better readers, at the time of the study, than those who learned later. One of the unschooling mothers, for example, noted that one of her daughters learned to read at age 5 and another not until age 8, but that the late-reading daughter, then age 14, "reads hundreds of books a year, has written a novel, and has won numerous poetry awards." A general claim of most of these parents was that their children love to read, regardless of the age at which they learned, precisely because they were never forced to read.

Motivated children can go from apparent non-reading to fluent reading very quickly. Some of the children progressed from non-reading to reading in what seemed to be a flash. For example, one unschooling mother wrote: "Our second child … didn't learn to read until he was 7. For years, he could either figure out what he needed to know from pictorial cues, or if stuck, would get his older brother to read to him. I remember the day he started reading. He had asked his older brother to read something to him on the computer and his brother replied, 'I have better things to do than to read to you all day,' and walked away. Within days he was reading quite well." Such step-like progressions in overt reading ability may occur at least partly because earlier, more covert stages of learning are not noticed by observers and may not even be noticed consciously by the learners.

Attempts to push reading can backfire. Three unschooling mothers noted that at some point they became impatient with their child's delayed reading and therefore attempted to teach reading, against their child's will and contrary to their own unschooling philosophy. All three reported that the attempt had a negative effect. For example, one mother wrote, "By age 9 … reading became a regular battle. He resisted it and found it boring and was distracted, so finally I got over my own schooly head … I said that I would never make him read again or even suggest it … Over the next months he quietly went to his room and taught himself to read."

Children learn to read when reading becomes, to them, a means to some valued end or ends. This principle is illustrated by most, if not all, of the reading case histories. For example, one of the Sudbury Valley students reported that he learned to read when he became jealous of other students who were reading and talking about the books they read. He said, "I wanted to join that club." An unschooling mother said that the first evidence she saw of her daughter's reading occurred when the daughter wanted to make brownies and nobody was willing to take the time to read

the recipe to her. Another wrote that her daughter, who didn't begin reading until age 11, was able to satisfy her love of stories by being read to, watching movies, and checking out CDs and books on tape from the library. She finally began reading because there was no other way for her to satisfy her interest in video games and magna books, which require reading that nobody was willing to do for her.

Reading, like many other skills, is learned socially, through shared participation. Vygotsky's idea that development occurs when children collaborate with more skilled others applies well to reading. For example, at Sudbury Valley non-readers and readers often play games together, including computer games, which involve written words. To keep the game going, the readers read the words aloud and the non-readers pick them up. Nearly all of the stories from unschooling parents included examples of shared participation in reading. One mother, for example, noted that her daughter, who learned to read at age 5, became interested in reading because of the family's regular Bible reading time. Before she could read she insisted on having her turn at Bible reading, "and she would just make up words as her turn!" The most common examples of shared participation are those in which readers read stories to nonreaders. The readers might be teenagers at Sudbury Valley, or parents or older siblings in unschooling families. Nonreaders look on, at the words as well as the pictures, and pick up some of the words; or they memorize books that have been read to them repeatedly, and then later they pretend to read the books while actually attending to some of the words. Pretend reading gradually becomes real reading.

Some children become interested in writing before reading, and they learn to read as they learn to write. Seven of the unschooling parents said that their child was interested in writing, or typing, either before or simultaneously with their initial interest in reading. For example, one wrote, of her 7-year-old son, "He is an artist and spends hours drawing things, especially stories and inventions. So naturally he wished to make his pictures 'talk' with captions, titles, instructions, and quotations. … There was a lot of 'MOM? How do you spell Superdog wants to go home?' I would spell out the sentence and five minutes later, 'MOM? How do you spell Superdog sees his house?'" This boy learned to read, at least partly, by reading the sentences that he, himself, had written.

There is no predictable course through which children learn to read. Every story of learning to read is unique. In natural learning, there is no right or wrong way. Many of our respondents expressed surprise at the sequence that their child went through in learning to read. Some children learned to read exotic words—like *hippopotamus* or *Tyrannosaurus Rex*—before they learned simpler words. Some, as I said, learned to write before they could read. Some seemed to be learning rapidly and then stopped for a year or more before progressing further. Most seemed to develop a large sight-reading vocabulary before they became aware of phonics, but a few seemed to become fascinated by the sounds of letters early in their learning. The best lesson we can draw from these varied stories is one of humility. We can enjoy watching children learn to read as long as we remember that it isn't our responsibility to push it along or modify the way it occurs. We're just observers and sometimes tools that children use for their own chosen ends.

Learning Math Without Formal Instruction

The question of how to teach mathematics has generated controversy rivaling that of how to teach reading. Numerous revolutions in math teaching have been tried, with little success. The one constant is that, however it has been taught, mathematics courses in our standard schools in the US have generated far more loathing of math than love of it and very little understanding of it. Math phobia is a major problem in colleges and universities, leading many, if not most, students to avoid mathematics courses when possible (Ashcraft, 2002). One expert on math phobia (Burns, 1998) contends, "More than two-thirds of American adults fear and loathe mathematics."

An Experiment in Which Less Teaching Resulted in More Learning

A fascinating, but little known, experiment on mathematics teaching was conducted in the 1930s by Louis Benezet (1935/1936), who at the time was superintendent of schools in Manchester, New Hampshire. In the introduction to his report on the study, he wrote, "For some years I had noted that the effect of the early introduction of arithmetic had been to dull and almost chloroform the child's reasoning facilities." All that drill, he claimed, had divorced the whole realm of numbers and arithmetic, in the children's minds, from common sense, with the result that they could do the calculations as taught to them, but didn't understand what they were doing and couldn't apply the calculations to real-life problems.

As a result of this observation, Benezet proposed an experiment that even in the 1930s seemed outrageous and would probably be impossible today. He asked the principals and teachers in some classrooms, in schools located in the poorest neighborhoods of Manchester, to drop arithmetic from the curriculum of grades 1 through 5. The children in those classrooms would be given no lessons adding, subtracting, multiplying, and dividing until they reached sixth grade. Children in the other classrooms would start such training in 3rd grade. He chose schools in the poorest neighborhoods because he knew that if he tried to do this in wealthier neighborhoods, where the parents were high school or college graduates, the parents would rebel.

As part of the plan, he asked the teachers to devote the time that they would normally spend on arithmetic to class discussions, in which the students would be encouraged to share and talk about any topics that interested them—anything that would lead to genuine, lively communication. This, he thought, would improve their abilities to reason and communicate logically. He also asked the teachers to give their pupils some practice in measuring and counting things, to assure that they would have some practical experience with numbers.

In order to evaluate the experiment, Benezet arranged for a graduate student from Boston University to test the Manchester children at various times in the sixth grade.

The results were remarkable. At the beginning of sixth grade, the children in the experimental classes, who had not been taught any arithmetic, performed much better than those in the traditional classes on story problems that could be solved by common sense and a general understanding of numbers and measurement. They were better not only than were the children in traditional classes in the poor-neighborhood schools, but also better than those in the wealthy-neighborhood schools. Of course, at the beginning of sixth grade, those in the experimental classes performed worse on standard school arithmetic tests, where the problems were set up in the usual school manner and could be solved by applying the rote-learned algorithms. But, by the end of sixth grade, according to Benezet, those in the experimental group had completely caught up on this and were still far ahead on story problems.

In sum, Benezet showed that children who received just 1 year of arithmetic, in sixth grade, performed as well on standard school calculations and much better on story problems than children who had received several years of arithmetic training. Today, whenever we find that instruction doesn't work well we conclude that therefore we need *more* of it and we need to start it *earlier*. Benezet showed that, at least for elementary school arithmetic, the apparent best practice is to teach *less* of it and to start it *later*! I suspect that a major reason for Benezet's results is that children naturally learn much about numbers in everyday life, so by sixth grade they have an understanding of real-world uses of numbers that allows them to learn calculations in ways that make sense and are not just rote.

Learning SAT Math at Sudbury Valley

Here's an observation about minimal math teaching that tops even Benezet's, though it's not the result of an experiment. At Sudbury Valley School, nearly every year, a group of students who plan to apply to competitive colleges approach a particular staff member for help in preparing for the mathematics portion of the SAT. In an interview, this staff member told me that the students who approach him are generally those who have the least previous experience with mathematics and the least long-term interest in it, but who know that they must perform well to be admitted into the college of their choice. Some have never previously studied mathematics in any formal way. Yet, they have acquired an understanding of such concepts as adding, subtracting, multiplying, dividing, fractions, decimals, percentages, and the like through everyday life experiences.

Beginning with their understanding of those concepts, the staff member efficiently leads them through all of the further background math that they need in order to read and understand the math SAT prep books, from which they complete their preparation on their own. Because the students have acquired basic numerical concepts in real life, and because they are motivated to do well on the SAT and are therefore attentive, they don't need to do hundreds of each type of problem. The staff member explains the rationale for solving each type of problem, the students solve a few

samples of it, and they've got it. Typically, he meets with the students for 60–90 min per week, for 6–10 weeks, and the students spend another 60–90 min on homework between meetings. That amounts to a range of about 12–30 h, total, of math study for students who may never before have taken a math lesson. The usual result, according to the staff member, is a math SAT score that is good enough for admission to the college the student wants to attend.

How Children Acquire Basic Mathematical Concepts in Play and Life

How do children acquire mathematical concepts without formal teaching? To address that, I conducted a survey of unschooling parents in which I asked them to tell me about any observations they might have made about how their children acquired such concepts. I received responses from 61 parents. In my informal qualitative analysis of the stories, I distinguished between *playful math* and *instrumental math* based on the child's motivation for learning (Gray, 2010a).

Playful math might also be called pure math; it is math for its own sake, motivated by the joy of discovery rather than a need to solve some practical problem. Playful math is to numbers what poetry is to words, or music is to sounds, or art is to visual perception. Four-year-olds are natural poets, musicians, and artists when they play with words, sounds, and colors and shapes; and they are natural mathematicians when they play with numbers. Playful math involves the discovery or production of patterns in numbers, just as poetry, music, and art involve the discovery or production of patterns in words, music, and visual space.

The earliest math play typically entails the discoveries that numbers come in a fixed sequence, that the sequence repeats itself in a regular (base-ten) way, and that once you understand the pattern of repetition there's no end to how high you can count. Many of the unschooling parents wrote of their young children's fascination with counting. For example, one wrote, "When [my 4½-year-old] found out about connect-the-dot drawings, it started to click for him how numbers proceed in order. He started counting aloud all the time … morning, noon and night … He is now at 5068. And when I tell people he is counting to one million, he says, 'No, ten million.' I hope I can survive it!"

In their continued math play, young children often discover the basic concepts of adding, subtracting, multiplying, dividing, and more. Here, for example, is a quotation about a child discovering the meaning of addition: "My younger son [age 5] was building with Legos while I was in another room, and he called out to me with a smile on his face, while jumping on the couch, 'Mom! What is 4 plus 4 plus 4 plus 4?' I said, '16.' He smiled and said, 'What is 8 plus 8?' I said, '16.' He smiled more and said, 'What is 2 plus 2 plus 2 … ' and he got exactly the right number of 2's to go to 16. It was clear that he knew the answers to these questions before he asked. These were not memorized from having been taught, but concepts that he figured

out from working with Legos and playing around with the numbers in his head and on his fingers. And he was thrilled to manipulate the numbers, all on his own. To him, it was a game."

Here's another quote, about a child discovering multiplication: "When he was 3 or 4, one day he went into our living room where we have a large window and noticed that there were four rows of seven panes. 'So,' he said, 'if I count to seven four times then it's 28.' I don't think we'd ever talked about multiplication at that point, but he'd essentially figured out how it worked and how to do it on his own from looking at the arrangement of squares. He began experimenting with it on his own, [putting] buttons in rows arrayed like the panes of glass. He still had to count up most of his answers because he hadn't committed them to memory, but he understood how it worked and what it meant."

And here's a story about a child discovering the concept of a square number: "One evening, at age 7, he had brought home a pack of Skittles. Like many kids, he likes to put them on a plate, sort them by color and play with them. On this day he had nine left and arranged them into three rows of three. He said, 'you know, the number nine is a square.' I told him that's what it's called, a square number, and that he could also make a square with four rows of four. He ended up making bigger and bigger squares … When it became impractical to keep making squares with skittles (too big), or perhaps because he was just getting bored with doing that, he used a calculator to find more square numbers and wrote them down."

Instrumental math is math used as an instrument (tool) for some practical purpose. Most of the math stories sent to me included at least some account of instrumental math. One unschooling mother listed a set of practical contexts in which her children learned to calculate: "All five kids learned to make measurements and read recipes, how to divide and how to double or triple a recipe's ingredients. They read maps and figured out the mileage. They all played various card games and board games that use numbers and/or reasoning skills—Uno, Skip-bo, Pinochle, etc. As they became involved in local sports, they learned how to keep the scorebook and figure out averages. One son learned how to make a spreadsheet to keep track of his team's batting averages. They all kept their own ledgers in their bank savings accounts."

Many of the stories that I classified as instrumental math were stories about play, in which the math was used as a tool (e.g., to keep score) and was not the primary subject of play. Here's a quotation from a mother whose children attended a school modeled after Sudbury Valley: "My kids have spent a lot of time playing online games. Real games, not those stupid educational ones. My 11-year-old son plays MapleStory and has figured out complex mathematical structures to play the game. 'If I want to buy this helmet for this amount, how many hours do I have to play making this amount per hour? If I sell this item in the market and the fee to sell is a certain percentage, how much will I have left after the fee? If I have this percentage of experience and I make a certain percentage per hour of experience, how many hours will it take to level up?' … Plus in the game you work with three different currencies and have to be able to translate back and forth among them regularly. Put these problems

isolated from the game context to a bunch of 5th graders in 'real' school and ask them to show their work and see what you get."

Stories such as these explain well why unschoolers and Sudbury students have little difficulty learning the formal math they need for SAT or ACT college admissions tests, when the time and desire comes for them to learn it. They are growing up in a world of numbers. They naturally play with numbers and use numbers in many aspects of their lives, and they thereby acquire basic mathematical concepts in contexts that make them real. Because this is all part of natural life, not forced and not judged, they learn math joyfully. They do not learn to fear and loathe it as so often happens with children in standard schools.

Conclusion

In an influential article entitled "An Evolutionarily Informed Education Science," Geary (2008, p. 187) concluded, "If our goal is universal education that encompasses a variety of evolutionarily novel academic domains (e.g., mathematics) and abilities (e.g., phonetic decoding as related to reading), then we cannot assume that an inherent curiosity or motivation to learn will be sufficient for most children and adolescents." My own conclusion, based on research examining education among children who do not attend conventional schools, is quite different. When children grow up in a literate and numerate environment, in which they regularly experience the written word and numbers and interact with people who read and use numbers, they indeed do learn to read, write, and calculate through their inherent curiosity and motivation to learn. Of course, those who choose to pursue, for example, mathematics at a higher level—beyond that needed for everyday life—may well do so by seeking formal instruction. There is nothing wrong with instruction, as long as it is self-chosen and not coerced.

One of the great strengths of an evolutionary perspective, at least in principle, is that it expands our frame of reference beyond the parochial here-and-now. It leads us to ask questions about human possibilities, not just about what happens given the constraints most people experience today. In our society today, it is rare for children not to attend schools where their natural ways of learning are deliberately shut off and, instead, they experience forced academic training according to a curriculum they did not choose. My research shows that, when we don't send children to conventional schools, but allow their curiosity and playfulness to continue to bloom, in an environment rich in self-educational opportunities, children learn to read, write, and perform numerical calculations without deliberate training, in their own ways and in their own time. They also discover their interests and passions, develop specialized skills in those realms, and often go on to successful careers that make use of those skills. The powerful educational instincts that evolved to meet the needs of our pre-agricultural ancestors still function beautifully today, if we provide young people with the conditions that allow those instincts to operate optimally.

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