Montessori

THE SCIENCE BEHIND THE GENIUS

Angeline Stoll Lillard

THIRD EDITION

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FIRST AND SECOND EDITION PREFACE

Twenty years ago, I was a Montessori skeptic. I had taken a Montessori teacher training course and was frustrated at not being able to discriminate scientifically supported ideas from mere opinion. I had met Montessori teachers who sometimes came across as more devoted to upholding their heroine than to learning about children. And I was convinced that while Montessori surely had its strengths, traditional and other forms of education surely had theirs too, and the best educational system would combine the strengths of each system.

When I embarked on graduate study in developmental psychology, I occasionally came across a study that happened to reiterate a major principle of Montessori, and I had seen enough of such studies by the time I had children to want them to be in a strong Montessori school if I could find one. (Not all Montessori schools would qualify, for reasons that will become clear in this book.) Having my children in a Montessori school led me to study Montessori practices more deeply, and I saw more convergences with research over time. The education director at my children's school, Trisha Thompson Willingham, asked me to write a column about these convergences for the school newsletter, and from that column this book was launched.

The delegates at Oxford University Press asked that I write a balanced assessment of Montessori, pointing out where the evidence is not supportive as well as where it is. I have done my best to do this, but there is a real problem. Their assumption, like my original one, was that Montessori must have aspects that are supported by research, and aspects that are not. Yet her major ideas—that there is a close relationship between movement and cognition, that the best learning is active, that order is beneficial for children, and so on—are supported by a strong body of evidence in developmental psychology. Some of her main developmental ideas that did not take hold until later and are rarely attributed to her are now mainstream, such as that children go through sensitive periods in development, and that language is (in a sense) innate. None of the Montessori ideas that I would consider central have been "disproven." Others are not researched. The most major idea that is not supported by the evidence is her negative view of pretend play, which I discuss at the end of chapter 5.[1] Like Piaget and others of her time, Dr. Montessori saw adaptation to reality as the goal of development, and pretending as a frivolous expression of immature minds that were not adapting to reality.

[1] In this third edition I retract this; see end of Chapter 6.

But there is another important point here: Dr. Montessori took her cue from children, observing them in her classrooms. She observed that when the children were offered toys alongside Montessori work, they chose the work and ignored the toys. They did not appear to be interested in pretending in the classroom. The reasons pretend play helps cognitive development may well be satisfied in other ways in Montessori classrooms.

For example, in play and in Montessori, children get to choose what to do, when, and with whom.

It is this practical approach that explains why Dr. Montessori is less "debunkable" today than Piaget. Like Dr. Montessori, Jean Piaget made many brilliant observations of children, based on their interactions with stimuli he developed. Piaget's aim through these observations was to explain the ontogenesis of intelligence, but for him theory came early, leaving him vulnerable to making observations that fit his theory. Dr. Montessori's aim was instead practical: She sought to develop a system of education that worked with children, rather than against them. Dr. Montessori was not particularly interested in theory; she was a physician, concerned with treatments to aid health and well-being. Surely her personal views did sometimes get in the way of objective observation, but her major ideas about treatments that bring about more optimal learning and development, based on her empirical observations, are largely upheld by research today. If schooling were evidence-based, I think all schools would look a lot more like Montessori schools. Yet Montessori schooling can often feel uncomfortable to parents, and even to the teachers who employ the methods, because it is different from what we had as children. For psychology researchers, attitudes toward Montessori are mixed: Some know enough to appreciate it, others misunderstood a small aspect and dismiss the entire approach. Very few know more than a smidgen about it.

In this book I try to make Montessori accessible to researchers, and I try to make psychology research accessible to parents and teachers. I hope the book will help readers better understand how people learn generally, as well as what happens in a Montessori classroom and why. I try to also point out Montessori ideas and issues that are unresolved in modern science and in need of more study. Empirical study should always be the deciding factor for how to best educate children, as it was for Dr. Montessori. Dr. Montessori described herself as an empiricist, but her research methods, although acceptable during her time, are no longer the standard.

I write about Montessori education because that is the alternative system that I know. Others who know Steiner (Waldorf), Reggio Emilio, and other alternative systems of schooling will surely see points of similarity to and differences from Montessori education. Those with knowledge of other systems can evaluate how they fare in relation to research on human learning and development.

THIRD EDITION PREFACE

In the 12 years since the initial publication of this volume, much new and relevant research has been conducted, and this has been incorporated. One change is a full chapter on executive function, a topic that was discussed briefly in the prior editions' chapter 3. Dr. Montessori put much emphasis on concentrated attention. In another case of the science following along behind Dr. Montessori's genius, executive function has become a very important research topic in developmental psychology and has been recently shown to be a very important predictor of life outcomes. Another new chapter covers research on how children in Montessori fare on academic and nonacademic outcomes; it focuses on research that has appeared from 2005 on. This research shows very strong outcomes for Montessori, particularly when it is implemented according to the plans and principles presented in Dr. Montessori's books.

Another noteworthy development, discussed in chapter 5, concerns pretend play. When I wrote the first edition, like many developmental psychologists I believed there was strong support for pretend play being an aid to development, and I mentioned it as one point on which Dr. Montessori was wrong. A group of graduate students and I subsequently conducted a careful review of that literature (Lillard et al., 2013) and concluded that the evidence that pretend play helps development is deficient. However, some conditions of pretend play—for example, it is freely chosen and reflects the child's interest, it often involves peers and movement, and its rewards are intrinsic—are known to be positive for development, and Montessori education shares these features with pretend play.

Another point is worth raising here. Anthropologists note that in cultures that resemble the standard conditions of human history, young children are not excluded from the daily routines of adults; they are active participants. Under such conditions, one sees less pretend play; and indeed, pretend play often involves children recreating adult routines in which they would like to participate (Lancy, 2009; Lillard, 2015). Dr. Montessori studied anthropology, and she developed Practical Life routines that allow children to engage in meaningful adult activities. She observed that in the classrooms she developed, children were more interested in doing real activities than in pretending.

Readers familiar with the first editions will notice other updates, such as research on organized classrooms, sensory discrimination and intelligence, epigenetics, and the Goldilocks effect, and on many other issues.

The 10 years of studying this vast and complex educational system and revisiting Dr. Montessori's books, as well as reading some anew, has deepened my understanding of and respect for this radically different approach to education. In essence, Montessori places a child in a special environment created to respond to human needs. In that environment, a child will become interested in something, often one of the specially created activities, and will begin to concentrate on that activity. Once concentration on a meaningful task begins, an array of changes takes place in the child. In concert with these changes, the child is given the keys to the universe: the Sensorial Materials that abstract the qualities of all things—weight, color, texture, temperature, and so on. The child learns to judge and discriminate those qualities, sharpening his or her perception. The world becomes more accessible, interesting, and understood, and the child moves on to other materials for learning; a life's journey has begun. What the Montessori system aims to do is so different from the aims of the conventional system, it is no wonder that Montessori gets sidelined in discussions of education. Our typical system of teaching children to take tests is so utterly impoverished by comparison.

I hope my deeper understanding of Montessori comes across in this volume, helps more readers to investigate well-functioning Montessori in practice, and leads to their understanding the possibilities Montessori could provide for children's development and a healthier human world.

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at Oxford, Catharine Carlin, helped see the manuscript through to the end, Steve Holt cleaned up the prose on the last draft considerably, and Christine Dahlin carried it through production. For this third edition, Joan Bossert was a terrific editor, and Lynn Luecken and Emily Perry fabulously carried it through production. My husband Bill Detmer came up with the title and was unremitting in his support. Like Montessori, he is ingenious, respectful of evidence, and full of love, and he inspired me at every step of the way. I am grateful to all these people for their enthusiasm and their help in making this manuscript a much better one than I ever might have on my own, and I take full responsibility for any mistakes that remain.

NOTES ON THE BOOK

It is difficult to write about a system that is named after a person. To differentiate the two, the person is always referred to as Dr. Montessori in this text, and the system simply as Montessori. Sometimes this leads to awkward contrasts (Dr. Montessori versus Piaget), but it clarifies references to the person versus the system.

I repeatedly refer to certain Montessori materials and lessons in this book, but these are only a tiny representative fraction of the entire set.

For convenience, I use the word "method" on occasion to refer to Montessori. Some will object, on the grounds that Montessori is much more than a method: It is grounded in a philosophy for life. Also, for convenience of expression, I sometimes use the word "curriculum" to refer to the entire set of Montessori lessons, although it is not technically like a traditional school curriculum.

Montessori

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An Answer to the Crisis in Education

The conceptions of the old schools, where teaching continues in the same way as in times profoundly different from ours, are clearly inadequate

—Maria Montessori (*1949/1979, p. 14*)

Two fundamental cornerstones of American schooling today were placed at the turn of the 20th century: the school as a factory and the child as a blank slate. Students of child development know that these ideas are obsolete, but they continue to have a profound effect on how schooling is done. The persistence of these outmoded ideas explains why so few children really flourish in school, and why so many strongly prefer snow days to school days. Yet for most of us, envisioning how to eliminate two such entrenched ideas is difficult.

Early in the 20th century, Dr. Maria Montessori did envision a radically different approach to education, an approach grounded in close and insightful observations of children rather than in adult convenience and misconception. Modern research in psychology suggests the Montessori system is much more suited to how children learn and develop than is the conventional system. In the chapters to come, I describe nine of Dr. Montessori's basic insights, recent psychological research concerning those insights, their incorporation into Montessori classrooms, and why they are often incompatible with conventional schooling. In this chapter I discuss the need for reform, and I trace the roots of the two misguided ideas that form the basis of typical American schooling. I close this chapter with an introductory view of Montessori education.

Dissatisfaction With Schooling

Children and adults alike often proclaim dissatisfaction with conventional schooling. William Blake (1794/1984) expressed the child's disenchantment in his poem *The Schoolboy*:[1]

> But to go to school in a summer morn,
> O, it drives all joy away!

[1] I am grateful to Mark Lepper for pointing out this poem and the Einstein example that follows.

Under a cruel eye outworn,
The little ones spend the day
In sighing and dismay.

Albert Einstein hired a scribe to take notes so he could skip classes to escape boredom (Schlip, 1949). Negative feelings toward school remain prevalent today: Children applaud the days when they are out of school, and adults frequently comment to children that they are lucky and must be happy when school is canceled. Children, of course, do not always know what is good for them, but education would be more successful were it not so frequently disliked. Indeed, a positive emotional climate within a classroom has been shown to be the most powerful predictor of students' motivation to learn (Stipek et al., 1998), and happier students are more engaged in learning in school (King, McInerney, Ganotice, & Villarosa, 2015); indeed, more happiness *leads to* better life outcomes (Lyubomirsky, King, & Diener, 2005). Positive moods are associated with more expansive and integrated thinking and learning and with detecting global patterns (Fiedler, 2001; Fredrickson, 2001; Gasper & Clore, 2002; Isen, 2000). A possible reason for this is that affective states provide information (Huntsinger, Isbell, & Clore, 2014). In this account, feeling good in school would inform students that they like school and like learning, resulting in fuller engagement, which then would lead to better performance. Infants have an intense drive to learn, and school-aged children maintain this drive for learning *outside* school (Bransford, Brown, & Cocking, 1999). Yet from the early years of schooling, children's motivation to learn *in school* steadily declines (Anderman & Maehr, 1994; Harter, 1981; Wang & Eccles, 2012).

Survey research reveals that adults are also discouraged with our schools. The 2014 Phi Delta Kappa/Gallup poll showed that 48% of people would give their local public schools a grade of C to F, and only 12% would give them an A—numbers virtually unchanged since 2003. To the nation's public schools, conversely, 80% of Americans assigned a C to F, and virtually none gave them an A. City schools are often of very poor quality, so families who can afford private schools choose them, and others ask for vouchers to expand their options. Millions of children sit on wait lists for public charter schools. Education seems to be in a state of constant crisis in this country.

The Pendulum Response

The U.S. response to this constant crisis has been to swing from conservative and traditional test-oriented programs to progressive and permissive ones, then back to test-oriented programs again, which is where we stand today.

A key feature of the U.S. Elementary and Secondary Education Act of 2001 ("No Child Left Behind")—the major multimillion dollar school reform act of this era—is its requirement that from 2006 on, all children in Grades 3 through 8 take standardized reading and mathematics tests annually, and schools are sanctioned if overall student performance does not improve. "Race to the Top," instituted in 2009 under President Barack Obama, adds Common Core standards as the basis for testing and teacher evaluation based in part on student test results. The current test-oriented program is driven largely by politicians, who must not be aware of research on the outcomes of such testing. When tests become the focus, teachers teach to and children learn to the tests (Jennings & Bearak, 2014). As is discussed in chapter 6, research has shown that when people learn with the goal of doing well on a test, their learning is superficial and quickly forgotten. This is to say nothing of the sad, widely publicized cases of school administrators and teachers cheating by altering student answers on such tests in Atlanta, Chicago, and Texas. The 2013 Phi Delta Kappa/Gallup polls show that American parents have very unfavorable views of standardized testing (http://pdkpoll2015.pdkintl.org/236).

The opposite swing of the pendulum, to more permissive, child-centered, discovery learning programs is also problematic, because in many instances, children in such programs fail to get a good grounding in the basics (Egan, 2002; Loveless, 2001; Mayer, 2004). Discovery learning occurs when key target information is not provided, and learners must discover it on their own. In some cases, extensive guidance is provided (more structured learning) and in others, there is no guidance (pure discovery learning). A recent meta-analysis clearly showed that pure discovery learning is a failure; children need structure to learn, and in fact learn better in guided discovery learning than conventional didactic programs (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). Yet progressive school programs have often lacked sufficient structure, and children's learning suffers. When this is noticed after a period in which innovative programs are tried, the pendulum swings back to traditional test-oriented programs.

Neither extreme addresses the basic problems with schooling. In fact, the record of distally instigated reforms for schools, such as No Child Left Behind, is not good: State and federal government–led changes in schools have not appeared to make any difference to learning (Wang, Haertel, & Walberg, 1993). Under No Child Left Behind, children occasionally appear to do better on the state-sponsored tests, sometimes because the tests are dumbed down to be easier; but their performance on some other standard measures has remained the same or has declined (e.g., see the recent Program for International Student Assessment [PISA] test results, available at www.oecd.org). One recent analysis using the National Assessment of Educational Progress (NAEP) tests as the standard showed a positive effect

on mathematics performance in fourth grade, but no influence on reading and no general improvement for eighth grade (Dee & Jacob, 2011); the 2012 PISA results also showed little to no improvement since 2009 (see http://nces.ed.gov/surveys/pisa/pisa2012/pisa2012highlights_6.asp; see also NAEP, 2012). It is an absolute travesty that politician-instigated school reforms are rarely based on sound research showing how children learn, but instead are usually based on people's personal intuitions.

Beyond this, however, is an even deeper problem. When anyone—be it an education professor, a school administrator, or a politician—considers school reform, the changes one tends to consider are rather superficial: this math curriculum or that one? Longer school day or longer school year? How many children per class—15 or 24? Education discourse in our country does not penetrate the roots of the problem, which are the underlying models on which our education system is founded. To really effect change, reformers must address the fundamental models on which our school system is built, as those models create a host of impediments to children's learning.

Two Poor Models

Conventional schooling is forever in turmoil because of its poor ideological foundation. First, conventional schools are modeled on factories, because the birth of mass public schooling coincided with the age of efficiency. Efficiency is a laudable goal, but it led to the creation of a school system that treats children as if they were all pretty much the same. In some ways they are, but in many ways they are not, and the factory model has a host of consequences that result in suboptimal learning conditions. We might also question its relevance to today's social and economic conditions, in which individual initiative, rather than blind obedience to the bells of a factory, is the key to progress. To wit, the earliest schooling of the founders of some of the most innovative and important technology interfaces today—Larry Paige and Sergey Brin of Google, Jeff Bezos of Amazon, Jimmy Wales of Wikipedia, and Will Wright of SimCity—was not in a factory system: all are Montessori school graduates. In Will Wright's (2007) TED talk, he speaks glowingly of Montessori school, which he attended through sixth grade; Montessori was "the high point of my education; from that point on everything else was pretty much downhill." The second poor model inherent in conventional schooling is an outmoded model of the child-learner inherited from behaviorism, in which the child is an empty vessel filled and shaped by deposited information, rewards, and punishments. The factory model and the behaviorist model work together in a mutually supportive fashion creating the conventional model we still typically use today.

THE SCHOOL AS FACTORY

Prior to 1850, the one-room schoolhouse was the dominant form of schooling in America. In such environments, education could be individualized, a wide age span of children occupied a single classroom, and teachers had significant independence in carrying out their didactic duties, responding only to a local board of directors. From the mid-19th century on, a change gradually took place as mass public schooling swept across the United States (and Europe). This coincided with the age of efficiency, in which a great deal of public discourse was focused on how to streamline business operations for maximum efficiency. Simultaneously, waves of immigrants were arriving on U.S. shores, intensifying the pressure for mass schooling. And by that point the Industrial Revolution had made factories a prominent organizational unit.

Because of this temporal synchrony, modern schools were consciously modeled on factories, with their priority of efficient operation (Bennett & LeCompte, 1990). Like factories, schools were expected to operate under then-popular "scientific management principles." In the public discourse, which Raymond E. Callahan documented in his classic opus *Education and the Cult of Efficiency*, schools were referred to as "plants," children as "raw materials," and teachers as "mid-level managers" (Callahan, 1962). Elwood Cubberly (1916/1929), then dean of Stanford University's School of Education, put it bluntly: Schools are "factories in which the raw products (children) are to be shaped and fashioned into products to meet the various demands of life" (p. 512).

One historic moment in this new approach to schools was the 1909 publication by a former school superintendent of Puerto Rico, Leonard Ayers. As secretary of the Russell Sage Foundation's Backward Children Investigation, Ayers ranked 58 school systems in various U.S. cities by their level of efficiency, meaning how many children moved up a grade each year (Ayers, 1909). Ayers was "one of the first educators to picture the school as a factory and to apply the business and industrial values and practices in a systematic way" (Callahan, 1962, pp. 15–16). His analysis was very influential, and low efficiency rankings had school boards across the country up in arms against their administrators. The notion of school as factory, efficiently using taxpayer money to produce educated final products, took firm hold in the wake of this publication.

At around the same time, Taylor management principles were being applied to many aspects of American life, beginning with efficient operation of factories but quickly extending to other businesses, the army and navy, the home, and schools. The aim of Taylor's principles was to increase production via scientific application of conservation practices. Ayers had popularized the goal of efficiency in education; Taylor showed the means. His principles specified

that to maximize efficiency, worker tasks had to be analyzed, planned, and controlled in detail by the factory manager. In the case of schools, the factory manager was the administrator. The workers, in this case the teachers, were to do as they were told.[2] Taylor management "was given national recognition at the 1913 convention of the Department of Superintendence when the main topic for discussion was 'Improving School Systems by Scientific Management'. There were scores of articles, books, and reports during the next decade on economy in education, efficiency in education, standardization in education, and the like" (Callahan, 1962, p. 23).

John Franklin Bobbitt, a University of Chicago education professor, prescribed steps for the training of teachers in the model of school as factory. School administrators were to tell the teacher training colleges what sort of teachers they needed, and expect those training programs to deliver. School administrators, he wrote, "have the same right to say to colleges what product shall be sent to them as a transportation system has to say to a steel plant what kind of rails shall be sent to it" (Bobbit, as quoted in Callahan, 1962, p. 88). Once the trained teachers arrived on the job, administrators were to tell teachers exactly how and what to teach. "The worker must be kept supplied with detailed instructions as to the work to be done, the standards to be reached, the methods to be employed, and the appliances to be used" (Bobbit, 1913, as cited in Callahan, 1962, pp. 89–90). Responsibility for teaching was switched from teacher to administrator during this era, which must have profoundly changed the teaching profession and hence schools. Administrators were urged to run the school as a business, teachers were dehumanized (likened to steel rails!), and the child was lost in this early 1900s discourse on how schools should be run.

Several practices that appear to prioritize adult convenience over children's welfare stemmed from these reforms. The practice of having single-age classrooms began early, apparently in 1847 in Quincy, Massachusetts (Nelson, 2002). Whole-class teaching is convenient for teachers and sensible if one has a particular model of children as learners (discussed later), but it also has high costs for children. Children of the same age are often at different levels within a topic. They can have different interests, which makes them benefit from somewhat different teaching. They can learn at different speeds and can be helped tremendously by interacting with other children who are older and younger than themselves. Whole-class teaching fits the factory model well, but not the child.

Another common practice instituted at this time was the "Gary" or "platoon" practice of shifting children from room to room every 50 minutes at the ring of a bell. This was instigated in the early 1900s (Bennett &

[2] In some discussions of the factory model, the children appear to be the workers, and the teachers, the mid-level managers.

LeCompte, 1990) as part of an effort to make schools more efficient in their use of space, but it eventually became integral to teachers' daily lesson plans. Conventional classrooms today still shift topics not when the teacher and children are at a good transition point, but when the bell rings. The teacher is responsible for timing the lesson to match the bells. Every classroom of children is different, but preestablished schedules restrict the possibility of children's needs guiding the lessons and their timing. Another drawback is that children can rarely pursue individual interests and activities, but instead have to follow the program that all the children follow, which is predetermined by the teacher or administrator. When it is math time, everyone must do math, no matter how engrossed some might be in a writing project. The world we are preparing children to work in today is not like this: Educated people often determine for themselves when to move from one piece of work to another. Yet the conventional school system still operates like a factory (Bennett & LeCompte, 1990).

The factory model and its consequences emerged from a need by school administrators to justify their use of tax dollars to produce educated citizens for a factory-based economy (Callahan, 1962). The school was yet another factory, producing workers for the factories into which they would graduate. What was best for the child was clearly not in view. It is interesting that schools have become more and more inefficient as laws have increasingly required schools to educate every child regardless of individual variation. Schools with diverse groups of immigrant children must accommodate several languages, schools that enroll many children with learning disabilities must provide special classes, and so on. The per-pupil cost of education in public schools averaged $11,014 in 2011-12 (National Center for Education Statistics, 2016). School spending has increased enormously over the past 30 years (Camera, 2016), with no difference in education outcomes.

Despite these problems, the factory model prevails today, and Taylor management principles are alive and well (Au, 2011). Children in conventional schools are still marched lockstep through an educational system, and even daily schedules and physical structures reflect the factory model. Indeed, these models are being driven downward (Hamre & Pianta, 2007; Zigler & Bishop-Josef, 2004), as shown by a comparison of kindergarten classroom time allocated to play versus academic subjects in 1998 and 2010 (Bassok, Latham, & Rorem, 2016). In our current information age, when we deal in more of a commerce of ideas and entrepreneurship than in factory production, use of such a model in education should be particularly suspect. The school system in a sense trains children to be alike, whereas the economy thrives on variations in individual initiative, at least at the levels to which most parents aspire for their children. The factory model makes poor sense both from the standpoint of how children learn and from the standpoint of what society seeks.

THE LOCKEAN CHILD

The second suboptimal model on which our schools are based is the child as empty vessel or blank slate, a view typically associated with the 17th-century philosopher John Locke. The early 1900s instantiation of this view was behaviorism, which is the view that one could elicit a number of different behavioral profiles in an organism by varying the consequences of its behaviors. The continued prominence of behaviorism in schooling is clear:

> We have inherited an education system designed in the early part of this century.... [This system's] espoused curriculum and teaching norms were based on prevailing scientific assumptions concerning the nature of knowledge, the learning process, and differential aptitude or learning. Although they have been profoundly challenged by the past three decades of research in cognitive science and related disciplines, the assumptions of the 1920s are firmly ensconced in the standard operating procedures of today's schools. (Resnick & Hall, 1998, pp. 90–91)

The Lockean or empty-vessel model of the child was adopted in schools of the early 1900s in part because it was embedded in school practices prior to that time. For example, in schoolrooms prior to 1900, rewards for good performance and punishments for poor learning were commonplace. These prior practices paved the way for behaviorism to become the prominent learning model during the period of transition from one-room schools to large public schools. Another important reason the model gained such prominence was the work of one of the great figures in behaviorism, Edward Lee Thorndike.

An eminent professor of psychology at Columbia University's Teachers College for 40 years, Thorndike vastly influenced teacher education. Still prominent today, Teachers College was then, when the field was still new, the foremost teacher-education institution. Its early PhDs became the establishing professors at other new schools of education across the nation. Thorndike was a man of such force, according to his dean, James Earl Russell, that he shaped not only the character of Columbia Teachers College, but also the entire field of teacher education in its infancy (Russell, 1926, as cited in Jonich, 1962). "Coming to the field of educational psychology in its early, formative days, Thorndike was able to dominate its course to an extent hardly possible to one man today" (Jonich, 1962, p. 2). Spreading his influence through writing as well, he published more than 500 articles and books, including a series of popular elementary school textbooks (Jonich, 1962).

Thorndike viewed the teacher as the major force in educating the child, and the teacher's task as being to change the child. To do so, he said, the teacher must "give certain information" (Thorndike, 1906/1962, p. 59) and "control human nature" (p. 60). The only means the teacher possessed to do

this were speech, gestures, expressions (p. 60), and a behaviorist curriculum based on associations between items learned and rewards administered.

To cement such associations, Thorndike argued that every topic should be broken down into discrete learning items on which students would then be drilled to form mental bonds. Well-formed bonds were to be rewarded with "kind looks, candy, and approval" (Thorndike, 1906/1962, p. 79), and poorly formed ones were to be met with punishment. Repetition was the key to well-formed bonds. Against any notion of discovery learning, Thorndike argued that bonds should be created for the information necessary, and no more.

An illustrative example of how Thorndike thought about necessary information concerns vocabulary. He believed that children should focus only on the most common words in the language, and he, therefore, published *The Teacher's Word Book*, listing the 10,000 most commonly used words in the English language (Thorndike, 1921b). Children's textbooks were considered useful to the degree to which they used these words, and few other "useless" (to Thorndike) ones (Hilgard, 1987). Evidently the age of efficiency and behaviorism were mutually reinforcing.

The Teacher's Word Book was but one of Thorndike's widely acclaimed books. His many textbooks supplied teachers with information already broken down into discrete learning items, and via these learning programs he wielded tremendous influence. His textbooks were adopted by the state school systems of California and Indiana. The income generated from sales of his textbooks across the United States was said to be five times his teaching salary in 1924 (Jonich, 1968, p. 400, as cited in Hilgard, 1987).

Thorndike's textbooks are classic illustrations of the decontextualized material common in U.S. textbooks today. For example, one Thorndike textbook problem is: "Tom had six cents in his bank and put in three cents more. How many cents were in the bank then?" (Thorndike, 1917, p. 18). The reader knows nothing about Tom or his bank, and so must process disembodied information. In contrast, the problems one regularly encounters outside school tend to have a meaningful context.

Thorndike believed that children could not transfer learning from one context to another unless elements of the situations were identical, so supplying context was useless. This belief was based on his 1898 dissertation, one of the most frequently cited studies in American psychology (Hilgard, 1987). In his study, adults were asked to estimate the area of different polygons (including rectangles), were then given feedback (training) as they estimated the area of rectangles, and, in a final test phase, were asked again to estimate the area of various polygons. Thorndike found that training on rectangles did not lead to improved performance on all of the polygons, but only on the rectangles. From this, he inferred a general principle that human learning does not transfer to different situations, and he concluded that one could and should therefore educate children merely by strengthening bonds for the very

information they needed to know, stripped of context. Thus, children were instructed in Thorndike's texts as follows: "Learn this: 1 dime = 10 cents. 1 nickel = 5 cents" (1917, p. 59). And so on. Thorndike's view that knowledge can and should be presented in textbooks, as a set of disembodied, unconnected written facts that children have to commit to memory to become educated beings, still dominates.

Psychological research since has quite clearly demonstrated that children are capable of transferring learning from one context to another, and that a more apt view of learning is that the child can construct knowledge, rather than simply form associations (Bransford et al., 1999; Kuhn, 2001; Peterson, Fenneman, Carpenter, & Loef, 1989). We also know today that learning with a meaningful context can be far superior to learning that is unconnected to its use. For example, street children who sell things show mathematical understanding that they cannot even apply to the decontextualized problems in schoolbooks (as discussed in chapter 8). Sometimes people have knowledge that they can use in everyday situations but cannot transfer to the more removed contexts of school. We also know that rewards can have detrimental effects on children's engagement in learning activities, and yet we continue to reward and punish children with grades. Schools today commonly use programs in which elementary school children "read for pizza" or other rewards (including money). Despite advances in our understanding of how children learn, the legacy of behaviorism is still quite clear in the textbooks, curricula, and methods of schooling in place today.

WHY POOR MODELS STICK

Over the years, several alternatives to the behaviorist view have been provided by educational theorists such as Dewey, Piaget, Bruner, and Montessori. These theorists are referred to as *constructivists*, because they view children as constructing knowledge, rather than simply taking it in like an empty vessel. When one takes a constructivist stance, meaningful settings become important for learning, because one uses tools and materials from the environment for that construction. Because constructivism aligns with results from recent research on children's learning, it is taught in schools of education. One might say that constructivism has won out over behaviorism in the halls of academe. However, although constructivism is taught in education courses today, research suggests that teachers have difficulty implementing the constructivist approach in U.S. schools. As a result, the approach has had waves of popularity followed by retreat (Zilversmit, 1993). John Dewey, America's most famous progressive educator, lamented near the end of his life that he had not made any real effect on schooling (Dworkin, 1959). Given that constructivism is a better model for learning, there must be strong reasons for its failure to penetrate schooling.

One reason, proposed by the historian Arthur Zilversmit (1993), is response to social and economic circumstances. He noted that retreats from constructivism have come at times of economic and social upheaval, such as the Great Depression and McCarthyism. At such times experimentation falls away in many domains as people opt for the comfort of familiarity. Conventional schooling, for all its faults, always offers the benefit of familiarity to adults who themselves were educated in conventional ways.

Another reason is that education students rarely fully understand constructivism and thus fail to implement it well (Renninger, 1998). When they begin teaching, the superficiality of their understanding becomes apparent, and they take up the conventional methods used by their own elementary and high school teachers. Conventional teaching fits both a teacher's memory and the culturally dominant view of what school is, and teachers who have less understanding of alternatives will naturally fall back on it.

Another reason, I believe, is that the very structure of schools, from physical arrangements to schedules to the ubiquitous use of textbooks and tests, supports behaviorist techniques and thereby leads teachers to take a fundamentally behaviorist approach. If the teacher has a desk in front of a blackboard at the front of the classroom and students are seated in rows facing the teacher, small group or individual work is unnatural. The physical format is designed for lecturing. Although elementary teachers in particular increasingly allow children to sit in clusters instead of rows, other physical learning structures still gear them toward the model of an empty vessel. Learning in conventional schools comes largely from books, even during years when children in conventional schools are not yet particularly good readers. Because of this, teachers must tell children the information that is in the books in order for children to learn. This can only be reasonably accomplished through whole-class teaching.

The 50-minute hour requires that all information be delivered in a set period, rather than allowing for fluid and flexible learning depending on the children's interests and needs. Standardized tests on factual knowledge require that a certain body of information be transmitted by a certain date. Standardized tests also embody a view of knowledge as a fixed set of formulas and facts that can be applied and circled on tests. The materials used in conventional schools are geared toward this inert view of knowledge (D. K. Cohen, Raudenbush, & Ball, 2002). Teachers have to work very hard to use unconventional methods in the face of all the structural support schools provide for the conventional method.

Another important reason we continually retreat from constructivist approaches is that with the exception of Maria Montessori, constructivists, in contrast to Thorndike, have not provided teachers with a broad, detailed curriculum. Dewey had many ideas that have stood the test of time, but he did not leave the legacy of a full curriculum. In the absence of a curriculum,

teachers who want to teach from a constructivist model of learning are on their own in figuring out how to implement the ideas. Because not enough teachers have succeeded in doing so well, the approach has repeatedly been branded as inadequate.

Few schools today have truly constructivist programs, and although teachers might leave schools of education versed in constructivist theories, their classrooms are run largely according to conventional schemes. Cook and colleagues demonstrated this in a case study of a star elementary education student as she moved from university coursework to practicum to classroom (Cook, Smagorinsky, Fry, Konopak, & Moore, 2002): At each step, the student endorsed a more behaviorist approach to teaching. Penelope Peterson and colleagues demonstrated the endorsement of behaviorist principles on a larger scale with a study of first-grade teachers (Peterson et al., 1989). However, they also noted that after about 15 years of experience, teachers returned to endorsing more constructivist views.

Although constructivists have had the greater influence in the academic world, behaviorists were "more influential on the practices in the conventional schools, which were always more numerous than the innovative ones" (Hilgard, 1987, p. 678). Despite research and teaching experience leading to a constructivist model of the child, elements of educational institutions—textbooks, the basic structure of the classroom, and so on—reinforce the Lockean model so much that it continues to dominate. Beyond the physical artifacts reinforcing the Lockean model are the collective memories of teachers and parents. When considering children and how to treat them, there is a strong tendency to revert to one's own childhood.

The same situation plays out today regarding a more recent rebirth of a Montessori idea in the context of traditional schooling: "differentiated instruction" (Tomlinson, 2014), which refers to individualized teaching based on students' needs and experience rather than the one-size-fits-all factory approach. Teachers fail to differentiate, even when they have been explicitly instructed and have learned how to do so, as indicated by paper tests, in part because the conventional school culture thwarts their efforts (Santangelo & Tomlinson, 2012). Finally, behaviorist methods appear to work in the short run. As will be discussed in chapter 6, once children are trained to study for rewards, removing the rewards negatively impacts learning. All these factors work in concert to impede school change.

Implications

The empty-vessel and factory models have many implications for schooling, which are discussed in the chapters to come. To preview, when the child is seen as an empty vessel into which one pours knowledge and then creates bonds,

there is no need to involve the child actively in the learning process: Empty vessels are passive by nature. Yet people learn best when they are actively engaged. Good teachers try to keep children active by asking lots of questions during lectures, but the physical structure of the classroom is designed for passivity: The child sits and listens to the teacher, who stands at the blackboard and delivers knowledge. There is no need to consider the child's interests in the prevailing model because empty vessels have nothing in them from which interests could stem. When interests do arise, because all vessels have been filled with the same stuff, all vessels should share interests. Empty vessels certainly cannot make choices, and so teachers or school administrators choose what should be learned, down to the micro-details tested on statewide examinations.

The factory model also has certain implications for schooling. Factories at the turn of the century were efficient because all raw materials were treated alike. Factory workers operated on material, and material was passive. The material was moved from one place to another, assembled on a set schedule. Based on the factory model, all children in a class are given the same information simultaneously and are often moved from one place to another at the ring of a bell. It is a significant strike against the factory model that even true factories are changing practices to improve long-term productivity by allowing teams of workers to develop products from start to finish rather than having the product moved from place to place (Wompack, 1996). Yet schools still operate like the factories of yore.

Innovations *are* happening in conventional schooling. Some people will read the chapters to come and respond that their own children's schools are incorporating evidence-based changes, making them more like Montessori schools—eliminating grades, combining ages, using a lot of group work, and so on. One could take the view that over the years, conventional schooling has gradually been discovering and incorporating many of the principles that Dr. Montessori discovered in the first half of the 20th century. However, although schooling is changing, those changes are often relatively superficial. A professor of education might develop a new reading or math program that is then adopted with great fanfare by a few school systems, but the curricular change is minute relative to the entire curriculum, and the Lockean model of the child and the factory structure of the school environment still underlie most of the child's school day and year. "Adding new 'techniques' to the classroom does not lead to the developmental of a coherent philosophy. For example, adding the technique of having children work in 'co-operative learning' teams is quite different than a system in which collaboration is inherent in the structure" (Rogoff, Turkanis, & Bartlett, 2001, p. 13). Although small changes are made reflecting newer research on how children learn, particularly in good neighborhood elementary schools, most of the time, in most U.S. schools, conventional structures predominate (Hiebert, 1999; McCaslin

et al., 2006; NICHD, 2005; Stigler, Gallimore, & Hiebert, 2000), and observers rate most classes to be low in quality (Weiss, Pasley, Smith, Banilower, & Heck, 2003). Superficial insertions of research-supported methods do not penetrate the underlying models on which are schools are based. Deeper change, implementing more realistic models of the child and the school, is necessary to improve schooling. How can we know what those new models should be?

As in medicine, where there have been increasing calls for using research results to inform patient treatments, education reform must more thoroughly and deeply implement what the evidence indicates will work best. This has been advocated repeatedly over the years, even by Thorndike. Certainly more and more researchers, educators, and policy makers are heeding the call to take an evidence-based stance on education. Yet the changes made thus far in response to these calls have not managed to address to the fundamental problems of the poor models. The time has come for rethinking education, making it evidence based from the ground up, beginning with the child and the conditions under which children thrive. Considered en masse, the evidence from psychological research suggests truly radical change is needed to provide children with a form of schooling that will optimize their social and cognitive development. A better form of schooling will change the Lockean model of the child and the factory structure on which our schools are built into something radically different and much better suited to how children actually learn.

Montessori Education

In the first half of the 20th century, Dr. Maria Montessori, a highly intelligent, scientifically minded woman who herself had been bored in school, decided to address the problem of education with a fresh outlook. In effect, she redesigned education from the ground up.

HISTORICAL OVERVIEW

How Dr. Montessori went about developing her program is an interesting story (Kramer, 1976; O'Donnell, 2007; Povell, 2009; Standing, 1957). She lived for much of her childhood in Rome and had unusual pluck and drive, aiming for a degree first in engineering and later in medicine, both unheard-of courses of study for a young Italian woman at the time. After her medical training, she worked in psychiatric clinics, where she became interested in helping mentally retarded children. At the beginning of the 20th century, mentally retarded people were often institutionalized in bare rooms, their food thrown at them. Dr. Montessori saw in their grasping

at crumbs of food on the floor as starvation not for food, but for stimulation. She studied the methods of Jean-Marc Itard, who had worked with the Wild Boy of Aveyron, and his student Eduard Seguin seeking methods of providing such stimulation. Seguin had developed a set of sensory stimuli for the education of retarded children, and Dr. Montessori adopted these in her work, creating what in Montessori terminology are called the Sensorial Materials.

In 1901, the mentally retarded children with whom Dr. Montessori had worked passed state educational tests designed for normal children, an event that aroused international attention. Newspaper articles the world over marveled at the amazing Italian physician who had brought "defectives" (as they were then called) to this feat. Dr. Montessori had a different reaction. Rather than marveling at what the mentally retarded children had done, she instead marveled that normal children were not doing better on such tests, given their obvious advantages. Then, as the famous Swiss psychologist Jean Piaget (1970) described it, "generalizing her discoveries with unparalleled mastery, Mme Montessori ... immediately applied to normal children what she had learned from backward ones: during its earliest stages the child learns more by action than through thought [, leading her to develop] a general method whose repercussions throughout the entire world have been incalculable" (pp. 147–48). Dr. Montessori turned her studies to the process of normal development in order to discover how human beings could reach their potential more fully than they did in conventional schools.

The process of application was not actually as immediate as Piaget described. First, following her success with retarded children, Montessori returned to school herself, this time to study education. She observed children in conventional classrooms to try to decipher why they were not advancing more in that environment. As she developed new ideas, Montessori requested permission to apply them in public elementary schools, but the governing bodies in Rome at the time would not give her access to those children. In retrospect, this limitation was probably providential, because the system she eventually developed for older, Elementary school children was based on children who had been in her Primary programs from ages 3 to 6. These children had at the outset a different set of skills and knowledge relative to other 6-year-olds, and the Elementary program could thus be built for children who were already reading and writing, who knew how to follow procedures and to make their own decisions about what to do next, and who understood some basic principles about how to get along as individuals in a large group.

Because she could not initially work in elementary schools, Dr. Montessori took an opportunity that arose to work with younger children. A housing project was undergoing renovation in a poor section of Rome, and children who were old enough to run about unsupervised but were not yet of the age

for school were causing problems in the renovated buildings. The project developers decided to intervene. Knowing Dr. Montessori was interested in working with normally developing children, they offered her a space in one of the projects and the care of 50 or 60 children, aged 3 to 6. A young woman served as teacher, and Dr. Montessori began her "experiment" in January 1907. She viewed her schools as laboratories in which to study how children learn best (Montessori, 1917/1965, p. 125).

Because legally the classroom could not be called a school, Dr. Montessori was not allowed to order typical school furniture or items, another limitation that ended up being advantageous. She furnished the classroom instead with small furniture she had specially designed for children. This furniture was typical of what one might find in a home, like small tables and armchairs. She put in various materials, gave the young teacher instructions on what to do, and then retreated to her other roles as a professor at the University of Rome, a researcher, a practicing physician, a renowned speaker on women's rights, and a student taking classes in education (Kramer, 1976). But she found time to observe the classroom, and the teacher also reported to her in the evenings about what had transpired. Dr. Montessori is said to have worked late into the nights making new materials for the teacher to try. By testing new approaches and materials and noting children's reactions, over the next 45 years, Dr. Montessori and her collaborators developed a radically different system of education.

Dr. Montessori developed materials for education in concert with ideas about it, and the materials were field-tested until she believed she had found reasonably optimum ones for teaching a given concept. She also tested materials across ages and frequently found a material appealed to children much younger than those for whom she had designed it. "We watched the younger children go among the older ones, and . . . we saw them become interested in things which we had thought previously too remote from their understanding" (Montessori, 1989, p. 68). Young children, she found, are much more capable than conventional curricula hold them to be, a finding that put her at odds with the educational trends of her time to lighten the curriculum for young children (Egan, 2002; Hall, 1911).

In contrast to other constructivists, Dr. Montessori left the legacy of a broad, field-tested curriculum covering all the major subject areas—math, music, art, grammar, science, history, and so on—for children ages 3 to 12. This system was developed by trial and error over her lifetime, with children in places as diverse as Rome, India, Spain, the Netherlands, and the United States. Dr. Montessori gave many lectures and wrote several books about her system, and she founded the Association Montessori Internationale (AMI) to carry on her work, including the training of Montessori teachers. A *Casa dei Bambini* operates today at the original location, at 58 Via dei Marsi near the University of Rome (Figure 1.1).

FIGURE 1.1 The *Casa dei Bambini* today at the original location, at 58 Via dei Marsi near the University of Rome. Photograph by the author.

A PORTRAIT OF A MONTESSORI CLASSROOM

For the next half century, Dr. Montessori adjusted and adapted her educational system to better serve children's needs, and well-functioning Montessori classrooms typically share many features reflecting those adjustments. The importance of several features is emphasized here; later chapters discuss psychology research pertinent to many of these features and more.

A Montessori classroom is usually a large, open-feeling space, with low shelves, different sizes of tables that comfortably seat one to four children, and chairs that are appropriately sized for the children in the classroom (Figure 1.2). Although not unusual today, making furniture that was appropriately sized for the children who would use it was one of Dr. Montessori's innovations (Elkind, 1976). Conventional Montessori classrooms always have at least three-year age groupings; at smaller schools all 6 years of Elementary might be combined.

The Montessori classroom is arranged into areas, usually divided by low shelving. Each area has "materials," the Montessori term designating educational objects, for working in a particular subject area (art, music, mathematics, language, science, and so on). This contrasts sharply with conventional education, in which learning is derived largely from texts. Books become more important as tools for learning at the Montessori Elementary level, but even there, hands-on materials abound. Dr. Montessori believed that deep concentration was essential for helping children develop their best selves, and that deep concentration in children comes about through working with their hands, hence, materials. Concentration is discussed at length in chapter 4.

FIGURE 1.2 A Montessori classroom. Photograph by An Vu.

Montessori classrooms also contrast with many conventional ones in having a pristine appearance. Extra materials are kept out of sight in a closet and rotated in and out of the classroom as children seem ready for or no longer in need of them. Every material has its place on the shelves, and children are expected to put each material neatly back in its place after use, ready for another child. Attention to the community and respect for the needs of others are highly valued. Such attention is also reflected in how teachers arrange the classroom. Materials both within and across subject areas are placed thoughtfully, so the arrangements make logical sense.

Children are not assigned seats but are free to work at whatever tables they choose, moving about during the day. They can also work on the floor atop small rugs. Children can choose to work alone or in self-formed groups, except when the teacher is giving a lesson. With very few exceptions, all lessons are given to individuals (more often in Primary, the 3- to 6-year-old level) or small groups (more often in Elementary, the 6- to 12-year-old level). Lessons are given as the children are ready for them; the teacher might write on the board or announce the day's planned lessons early in the day, so that children will know what to expect. Care is taken so that the effect is not to impose control on the children, but simply to alert them so they can plan their day accordingly.

Montessori education is organized to the core. At the preschool level, this sometimes puts people off. They enter a Montessori classroom, and unlike preschools they normally see, it is very quiet. Children are calmly working alone or in groups. And their work is organized. They are concentrating, carrying out activities in a series of steps that have been shown to them by the teacher or other children. As will be discussed in chapter 10, research suggests that orderly environments are associated with the best child outcomes, but the degree of order can make parents feel uncomfortable.

The materials on the shelves are designed to attract children's interest and to teach concepts via repeated use. Most of the materials are made of wood and are either natural or painted in bright colors selected because those colors were found to attract children. Each material has a primary reason for its being in the classroom; most also have several secondary purposes as well. Rather than giving tests to assess competence, Montessori teachers observe children at work, noting whether children use the materials correctly. Correct use is believed to engender understanding. Teachers repeat lessons when children appear to be using a material improperly and thus will not draw from it the learning it is intended to impart; new lessons are given when children appear to have mastered a material and to be ready for the next material in a sequence.

In keeping with each material's having a primary purpose, there are particular ways to use the materials, which the children are shown in the lessons. Children are not supposed to make music with Metal Insets (a material shown in Figure 1.3, consisting of standard geometric shapes made of metal,

FIGURE 1.3 The Metal Insets. Photograph by An Vu.

each inside a square metal frame); the Metal Insets serve other purposes, and different materials are provided that are more suited to making music. In addition to the use of each material being highly structured, the overarching Montessori curriculum is also tightly structured. Materials within a curriculum area are presented in a hierarchical sequence, and there is a complex web of interrelationships with materials in different areas of the curriculum. As far as I know, no other single educational curriculum comes close to the Montessori curriculum in terms of its levels of depth, breadth, and interrelationship across time and topic.

The materials break important activities into a series of organized steps that children learn separately before bringing them together to do the main activity. These steps often constitute indirect preparation; children are not aware of what the steps can lead to, but the teacher is aware and presents the materials methodically. A good example of how instruction in Montessori proceeds is in the teaching of writing and reading.

LEARNING IN MONTESSORI: WRITING AND READING

In Montessori programs, children learn to write before they learn to read, and reading follows spontaneously several months after writing has begun. Several steps lead to the onset of writing in the Montessori Primary classroom. Three-year-olds first engage in activities through which they practice the thumb–index finger (pincer) grip needed for holding a pencil. One exercise that uses this grip involves lifting solid Wooden Cylinders by their small round knobs out of an oblong wooden case (Figure 1.4). There are four sets of these Wooden Cylinders. The cylinders in one set vary systematically in

FIGURE 1.4 The Wooden Cylinders. Photograph by An Vu.

width while height remains the same, those in another vary in height while the width remains the same, and those in a third change by both height and width together. The fourth decreases in width and increases in height. The exercise of lifting the cylinders out, mixing them up, and then returning them to their appropriate holes was designed primarily to educate the child's intelligence by engaging the child in an activity requiring that he or she observe, compare, reason, and decide (Montessori, 1914/1965). Focusing on dimension with this exercise also prepares the child for math, and the work enhances the child's powers of observation and concentration. But the addition of the knobs allows the material to confer two additional benefits geared toward writing: strengthening the finger and thumb muscles and developing the coordination needed for holding a pencil.

The child goes on to develop the wrist action associated with writing by tracing shapes from the Geometry Cabinet, a wooden cabinet containing several trays, each holding six blue two-dimensional wooden shapes set in natural wood frames (Figure 1.5). One tray holds rectangles of gradually increasing widths; another has different triangles (equilateral, right angle, isosceles, and others); another has a set of irregular geometric shapes, such as an ellipsoid and a parallelogram, and so on. Children learn the names of the shapes as they trace along their edges, first with their fingers, developing lightness of touch and the wrist action needed for writing. Later they trace the outlines of leaf shapes in the Botany cabinet, but use a delicate orange stick that allows them to get into the corners (Figure 1.6). This delicate orange wooden stick allows children to practice holding something pencil-like, but without the added concern of making marks that would damage the material. Children learn the names of various shapes of leaves while also (without knowing it)

FIGURE 1.5 Triangle Tray from the Geometry Cabinet. Photograph by An Vu.

FIGURE 1.6 The Botany Cabinet. Photograph by An Vu.

learning the wrist action and pencil grip for writing. Even prior to using the orange wooden stick, "The little hand which touches, feels, and knows how to follow a determined outline is preparing itself, without knowing it, for writing" (Montessori, 1914/1965, p. 96). Clear writing is exact, and such exercises prepare children by engaging them in precise movements.

Later, children learn to hold and use pencils with the 10 Metal Insets (see Figure 1.3), which have the same geometric shapes as the items from the Geometry Cabinet, but are made of metal, with the outer frame painted red and the inset geometric shapes painted blue. Metal is an unusual choice for a Montessori material because metal is cold to the touch; wood is the norm because it feels warmer, and Dr. Montessori perceived this as inviting use. However, metal has the advantage of not being as easily marked by straying pencils, and thus it is the material of the first objects with which children use actual pencils. The child initially sits down with all 10 Metal Insets at once, as Dr. Montessori noticed this inspired children to do all of them, whereas having just one did not (Montessori, 1914/1965, p. 144).

Each of the Geometry, Botany, and Metal Inset items has a small knob like those the children first encountered with the Wooden Cylinders, so working with these materials continues to exercise the pincer grip in preparation for holding the pencil. Dr. Montessori intended that exercising such muscles would prevent fatigue when children first begin writing. When 4-year-olds start writing in Montessori, as teachers describe it, they want to do so nonstop. If these exercises really do strengthen the pincer grip, they might support an early enthusiasm for writing. In addition, Montessori teachers pay close attention to whether children are correctly holding the pencil, another step thought to reduce the muscle fatigue that can come from a great deal of writing.

With the Metal Insets, children use 10 colored pencils to trace inside the red frame or along the outside of the inset shape. Later they work on filling in the inset drawings with lines, to work on pencil control (Figure 1.7). The repeated use of 10 objects (pencils, Metal Inset shapes, and so on) is intentional in Montessori, to reinforce the decimal system. Markers were, of course, not available when Dr. Montessori developed this system, but many Montessori schools today eschew the use of markers because pencils provide the children with more finely tuned feedback. The intensity with which the child presses a pencil onto paper has immediate and visible consequences: A pencil tip will break if pressed too hard and will not make a mark if not pressed hard enough. In addition, pencils allow shading, and one exercise with the Metal Insets is to shade the inside of a shape from darkest to lightest. Markers do not educate the child as carefully, because no immediate touch-dependent feedback results.

Colored pencils and Metal Insets are later employed to make a wonderful variety of creative illustrations in art, an area many people mistakenly

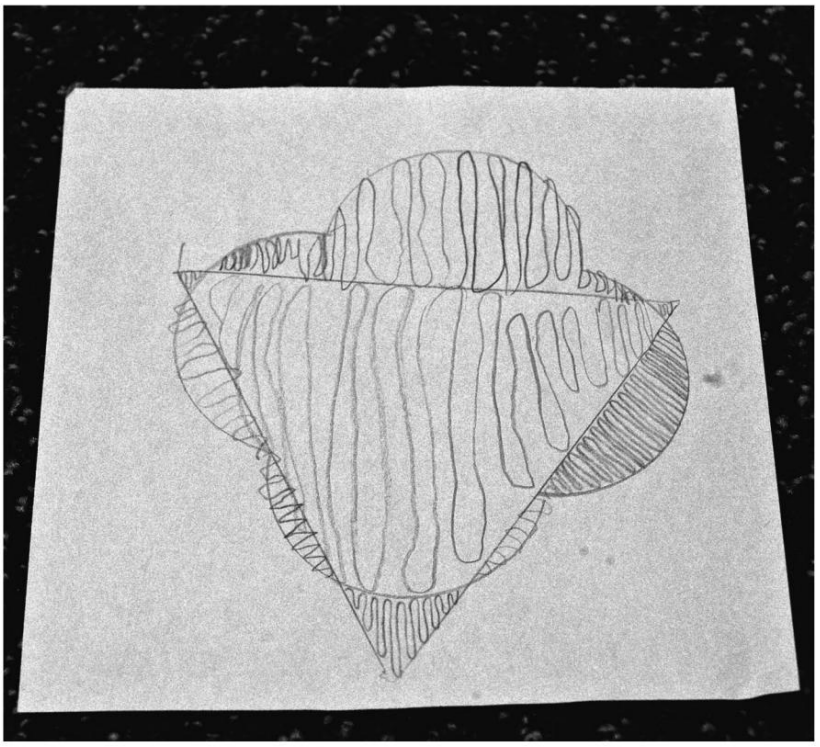

FIGURE 1.7 Metal Inset designs. Photograph by An Vu.

think is not part of the Montessori curriculum (e.g., Stodolsky & Karlson, 1972). The same misconception is often found regarding music, although Montessori also has a full music curriculum. Not all Montessori teachers implement the full curriculum, sometimes because their training courses are of insufficient duration to cover it (e.g., the Tone Bars, used for musical composition, in Figure 1.8, are sometimes absent from Elementary classrooms for this reason). Indeed, Dr. Montessori used 2 years to teach the Elementary curriculum to teachers, whereas the longest-running Elementary training courses today teach it in a year.

After learning to trace the Metal Insets, children learn to draw a series of connected parallel straight lines inside of the frame, which teaches children to control the hand and pencil in the natural flowing motion of writing. Dr. Montessori saw this flowing motion to be easier for children than stopping and lifting the pencil frequently, so she had children learn cursive writing before learning to print.

During the same period when children are using the Metal Insets in these ways, they are also learning to trace cursive Sandpaper Letters with their fingers, following the same paths of motion one uses to write. As they trace the letters (shown in Figure 1.9), children learn to say the phonetic sound (not the name) associated with each letter. Later, the Metal Inset and Sandpaper

FIGURE 1.8 Montessori music: composing on the Tone Bars. © Laura Joyce-Hubbard, 2014. All rights reserved.

Letter activities come together. Children hold pencil to paper while making the same hand motions they made with the Sandpaper Letters, saying the sounds of the letters, and eventually stringing letters together to write words in cursive. This process is also assisted by the provision of the Movable

FIGURE 1.9 The Sandpaper Letters. Photograph by An Vu.

Alphabet, a wooden box of cardboard letters that children use to make words (shown in Figure 5.5).

There are more materials and also forms of these materials that lead to writing, but this description gives a flavor for the carefully organized curricula a child is given in a Montessori classroom. The outcome of using the materials in this carefully orchestrated sequence, for most children who enroll in Montessori as older 2- or young 3-year-olds, is to be easily writing in cursive during the year when they are 4. Reading emerges spontaneously during the months after writing begins.

Research suggests many long-term advantages for early reading (Mol & Bus, 2011). Eleventh-graders' vocabulary, reading comprehension, and general knowledge were all strongly predicted by their reading ability 10 years earlier, when they were in first grade, even when cognitive ability was controlled for (Cunningham & Stanovich, 1997). There is also support for Montessori's phonemic approach to early reading over the less successful whole-language approach (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). Preschoolers who were trained in phonemic awareness scored significantly higher on tests of reading comprehension 3 years later, relative to children in a matched control condition (Byrne & Fielding-Barnsley, 1995). Montessori's haptic approach to learning to read, by first tracing letters while making their sounds, has also gained support in recent research. French preschoolers who were taught to either just look at letters, or look and trace the letters, while making the associated sounds were later given letter–sound and pseudo-word recognition tests (Bara, Gentaz, & Cole, 2007). The haptic group performed significantly better on the latter, and showed a trend to being better at the former. In another study, among children who were twice read alphabet picture books, those who traced block capital letters made of sandpaper learned to recognize letters at a level significantly greater than chance, whereas children who did not trace the letters or traced plain paper letters were at chance (Chiong & DeLoache, 2013). Research has also shown (not surprisingly) that the more one reads, the more one knows, controlling for intelligence and for years of education (Stanovich & Cunningham, 1993). Long-range reading skills are best predicted by a young child's degree of interest in reading (Whitehurst & Lonigan, 1998). Obviously, making reading unpleasant early on by putting children through a difficult and laborious process would not instill enjoyment of reading, and enjoyment of reading is characteristic of those who read a lot.

Unlike the laborious process most first-graders go through, learning to read and write in Montessori appears to be a painless process for children. The organized approach Dr. Montessori took to the learning process would seem to be part of why it seems easy. She performed task analyses of different areas, and the Montessori curriculum presents the child with a series of manageable steps in each area, aimed at mastering each task. The steps, derived

from observations of children, are carefully organized, focus on important skills and information, and culminate in the child's mastery. Moving to a larger scale, these observations led to a method of schooling with a different model of the child and the school than those that prevailed in conventional schooling.

Montessori Models of Child and School

Underlying Montessori education is a model of the child as a motivated doer, rather than an empty vessel. The active child is a view often credited to Jean Piaget, who may have been influenced by Dr. Montessori. He was 26 years her junior and early in his career had conducted observations for his book *The Language and Thought of the Child* in a Montessori school. He apparently attended at least one Montessori conference, in Rome in 1934, and was president of the Swiss Montessori Society. Letterhead from the early days of the AMI lists Piaget as one of its sponsors (Kramer, 1976). Thus it is not surprising that Piaget and Montessori's theories share some crucial ideas, such as the notion of children as active learners (Elkind, 1967). Children in Montessori classrooms work as motivated doers, learning through self-instigated actions on the environment.

The model of the school in Montessori education is also different. Rather than being modeled on the factory, a Montessori school seems more like a miniature and eclectic university research laboratory. Montessori children pursue their own projects, just as do researchers in their laboratories. Like university researchers, children choose what they want to learn about, based on what interests them. They get lessons across the curriculum, which bears some similarity to researchers going to colloquia or conferences to learn about new areas or techniques. The children talk with and collaborate with colleagues of their choosing. They pass on the fruits of their labors to others by giving talks to the class or other classes in their school and writing up papers. Thus, in Montessori, the child can be seen as a motivated doer in a research university, versus the conventional school model of the child as an empty vessel in a factory.

This book describes nine insights Dr. Montessori derived through her observations of children that undergird her approach to schooling. These insights are supported today by a good deal of research in psychology and education. Some of the principles can also be implemented in conventional classrooms; in fact, some of the research showing the validity of the principles was conducted in conventional school contexts. However, to develop a system from a principle is very different than to insert a principle into a system that was designed with something else in mind. The nine principles I discuss emerged in the early days of Montessori education, through Dr. Montessori's

observations of children's behavior in classrooms that were unusual to begin with. The principles coexist and are deeply engrained in the Montessori system.

Nine Principles of Montessori Education

The nine principles of Montessori education discussed in the following sections are:

1. Movement and cognition are closely entwined, and movement can enhance thinking and learning.
2. Learning and well-being are improved when people have a sense of control over their lives.
3. The ability to direct one's attention in a sustained and concentrated way fosters an array of positive developments and is itself trainable.
4. People learn better when they are interested in what they are learning.
5. Tying extrinsic rewards to an activity, such as money for reading or high grades for tests, negatively impacts motivation to engage in that activity when the reward is withdrawn.
6. Collaborative arrangements can be very conducive to learning.
7. Learning situated in meaningful contexts is often deeper and richer than learning in abstract contexts.
8. Particular forms of adult interaction are associated with more optimal child outcomes.
9. Order in the environment is beneficial to children.

MOVEMENT AND COGNITION

The first principle is that movement and cognition are closely entwined. This observation makes sense: Our brains evolved in a world in which we move and do, not a world in which we sit at desks and consider abstractions. Dr. Montessori noted that thinking seems to be expressed by the hands before it can be put into words, an idea with which Piaget apparently concurred (Ginsburg & Oper, 1979). In small children, she said, thinking and moving are the same process. Piaget restricted this identity claim to the sensorimotor period, but, consistent with recent work in psychology, Dr. Montessori saw at least a close relationship between the two processes continuing past age 2. Based on this insight, she developed a method of education in which a great deal of object manipulation occurs. In recent years, there has been an explosion of fascinating research on the connection between movement and cognition that speaks to Dr. Montessori's ideas about movement's importance

to thought. The findings imply that education should involve movement to enhance learning.

CHOICE

A second principle is free choice. Dr. Montessori noted that children seemed to thrive on having choice and control in their environment, and she envisioned development as a process of the child's being increasingly able to be independent in his or her environment. Although good Montessori programs impose definite limits on this freedom, Montessori children are free to make many more decisions than are children in conventional classrooms: what to work on, how long to work on it, with whom to work on it, and so on. Research in psychology suggests that more freedom and choice (within a carefully designed, ordered structure; see the "Order in Environment and Mind" section) are linked to better psychological and learning outcomes, as shown in chapter 3.

EXECUTIVE FUNCTION

A third principle is that the development of executive control, especially the ability to focus and sustain attention, is key to other important developments. Dr. Montessori noticed this early in the school in San Lorenzo, when a child became so engrossed with a set of Wooden Cylinders that she was able to lift the armchair in which the child was working and not disturb the child's concentration. Dr. Montessori realized that developing this ability to concentrate was associated with changes in personality that she called "normalization." This principle is new to this edition, because only in the last 10 years has research on this burgeoned both in developmental psychology and in research on the positive effects of meditative practices. These are reviewed in chapter 4.

INTEREST

A fourth principle is that the best learning occurs in contexts of interest. Interest can be more personal, as when an individual has an abiding interest in ladybugs or dogs that seems to come from within, or it can be situational, an interest that would be engendered in many people exposed to such events and activities. Dr. Montessori created situational interest in part by designing materials with which children seemed to want to interact. She also trained Montessori teachers to give lessons in a manner that would inspire children, for example by presenting just enough information to pique curiosity and by using drama in their presentations (particularly with Elementary-aged children). Montessori education also capitalizes on

interests that appear regularly at particular times in development, such as the intense interest children have in learning language in the preschool years. Dr. Montessori noted that young children seem to be driven to acquire word labels for the objects in their environment, so in the Primary classrooms, children are given a great deal of vocabulary. Montessori education also capitalizes on unique individual interest. Children pursue learning that is of personal interest to them—not in a manner that excludes large swaths of curriculum, but in a manner consistent with how we know the very best learning takes place. Rather than memorize facts chosen by a faraway state legislative body, children in Montessori Elementary schools write and present reports on what fascinates them, tying it into the foundational curriculum. The Montessori materials and basic lessons ensure a core of learning across curriculum areas, but each child's imagination is invested in the particular avenues of learning that the child pursues beyond that core. These topics are discussed in chapter 5.

EXTRINSIC REWARDS ARE AVOIDED

Dr. Montessori saw extrinsic rewards, such as gold stars and grades, to be disruptive to a child's concentration. Sustained, intense periods of concentration are central to Montessori education. Dr. Montessori recounts children repeating problems (such as getting the Wooden Cylinders into their proper holes) dozens of times in succession, displaying a level of concentration that she herself had previously thought young children were incapable of. At the Primary level, children might concentrate intensely for 30 minutes at a time. By the Elementary level, they might work on the creation of a single chart for much of the day or even several days in succession. The rewards in Montessori education are internal ones. A good deal of research suggests that interest in an already-loved activity, such as learning seems to be for most children, is best sustained when extrinsic rewards are not part of the framework, as discussed in chapter 6.

LEARNING WITH AND FROM PEERS

In conventional schooling, the teacher gives the children information, and children rarely learn from each other or directly from materials (except texts, which often tell children rather than helping them discover). Although on the increase, working together is still rare in (conventional) elementary classrooms, where tests, problem sets, and papers are usually if not always done alone. In conventional preschool classrooms, in contrast, children usually play in groups. Montessori education is opposite in these arrangements, and is actually more in line with what developmentalists know about children: Younger children are more apt to play side by side but not necessarily together, whereas elementary-age children are intensely social.

In Montessori Primary classrooms, children may often work alone by choice, but in Elementary classrooms children are rarely seen working alone. They pursue knowledge in self-formed groups, creating products ranging from reports to dioramas, charts to plays, and timelines to musical scores. They leave the classroom together in small self-created groups to interview people outside the school or to visit museums or businesses that are relevant to a current project stemming from their own interests. Asked what happens in these small learning groups when one child understands better than the others—a concern that arises out of the individualistic conventional model in which one child might do most of the work—I recently heard a 9-year-old Montessori child respond, "We help each other." Chapter 7 discusses research on what happens when students work together to learn, rather than working as individual units striving for the highest grades.

LEARNING IN CONTEXT

In conventional schooling, children sometimes learn without understanding how their learning applies to anything besides school tests. Dr. Montessori reacted to this by creating a set of materials and a system of learning in which the application and meaning of what one was learning should come across to every child. Rather than learning largely from what teachers and texts say to them, children in Montessori programs learn largely by doing. Because they are doing things, rather than merely hearing and writing, their learning is situated in the context of actions and objects. For example, as described earlier, children go out of the Elementary classroom and into the world to research their interests. A small group of children who have become interested in bridges, for example, may choose to locate a local engineer who will meet with them to explain how bridges are designed. This approach, sometimes referred to as "situated cognition," reflects a movement in education that goes alongside current interests in cultural psychology, apprenticeship, and how people learn through participating in their culture. Evidence concerning the validity of this approach is reviewed in chapter 8.

TEACHER WAYS AND CHILD WAYS

Dr. Montessori's recommendations on how teachers should interact with children anticipated later research on parenting and teaching. When adults provide clear limits but set children free within those boundaries, and sensitively respond to children's needs while maintaining high expectations, children show high levels of maturity, achievement, empathy, and other desirable characteristics. Conventional schools have sometimes erred by being too authoritarian, conveying a "do it because we said so" attitude that is not associated with positive child outcomes. When progressive schools fail, it may

sometimes be because they trade the authoritarian teacher-centered features of many conventional schools for their opposite: permissive, overly child-centered ones. Dr. Montessori prescribed a third style, one consistent with what is called authoritative parenting and known to be associated with the most optimal child outcomes. Her advice to teachers is reminiscent of the adult styles associated with positive child outcomes in other domains as well. This research is reviewed in chapter 9, "Adult Interaction Styles and Child Outcomes."

ORDER IN ENVIRONMENT AND MIND

Montessori classrooms are very organized, both physically (i.e., layout) and conceptually (i.e., how the use of materials progresses). This organization sometimes turns people off: It seems finicky, even obsessive-compulsive. Yet research in psychology suggests that order is very helpful to learning and development, and that Dr. Montessori was right on target in creating very ordered environments in schools. Children do not fare as well in less ordered environments. Chapter 10 reviews research on order and its effect on children. It also speculates on the potential neurological impact of presenting orderly sequences of materials intended to tune the senses.

Further Montessori Insights

Dr. Montessori also forecast other current ideas in developmental psychology not reviewed here. For example, she drew extensively on the idea of sensitive periods, which she credited to Hugo de Vries, the Dutch horticulturist best known for rediscovering Mendelian inheritance. Developmental scientists consider sensitive periods to be times when an organism is particularly primed to develop in certain ways, given certain environmental stimulations (Bornstein, 1989). It was many years later that Konrad Lorenz popularized this notion with strong evidence of such periods in goslings, and ethological theory began to be incorporated into theories of human development. Among other sensitive periods, Dr. Montessori identified the first 5 years as a sensitive period for language in children. She went so far as to claim the innateness of human language (Montessori, 1967a/1995) years before Noam Chomsky (1959) rocked the world of psycholinguistics with that same claim. She talked repeatedly of how important early experience is to development (Montessori, 1967a/1995), well before research in neuroscience backed that idea (Bransford et al., 1999). She also considered development to continue all the way to age 24, about the age when gray matter volume stops increasing in the human brain (although white matter—the myelinated connections between neurons—continues to increase thereafter) (Lebel & Beaulieu, 2011;

see also Gogtay et al., 2004; Lillard & Erisir, 2011). In these and other ways, Dr. Montessori was clearly well ahead of her time. A natural question at this point is whether the educational system she developed, which incorporated such insights, has outcomes that are superior to those of conventional schools. In the following section I will review research that had been conducted prior to the first edition of this volume in 2005. Chapter 11 covers research done since that time, including my own studies that were inspired by what I had learned in writing this book.

RESEARCH ON MONTESSORI OUTCOMES

Most published work on Montessori shows positive outcomes; however, like most fieldwork on education outcomes, the findings must be taken with a grain of salt because of methodological shortcomings. Good research on the effectiveness of different school programs is actually very difficult to do (Mervis, 2004). One common shortcoming is lack of random assignment: Parents elect to send their children to Montessori programs. Features of parenting tend to swamp features of schools when it comes to education outcomes. Parents who happen to like Montessori programs might be, by and large, excellent parents: They like order, they like children to be able to make choices, and so on. Such parents would incorporate those features into the child's home life, and the additive benefit of having those features in school might be nil. A research study comparing such children with children not in Montessori would thus show differences, but the cause of the differences would actually be the parents, not the school program. In the absence of random assignment, one can always argue that parenting or some other variable was the source of difference.

Some of the first research on Montessori outcomes was done in Head Start programs in the 1960s (Karnes, Shewedel, & Williams, 1983; Miller & Bizzell, 1983, 1984; Miller & Dyer, 1975). Two Great Society-era studies addressed the self-selection problem by randomly assigning children into different Head Start programs and looked at long-term outcomes. Montessori was one of several programs compared. The Miller study, in Louisville, followed children through 10th grade, and the Barnes study, in Urbana, Illinois, followed children through high school. Results are described in some detail in the following paragraphs, but the main thrust was that initial results did not favor Montessori, yet longitudinal results did.

It is important to note, however, that regarding fidelity, these Montessori Head Start programs left much to be desired. In the Louisville study, there were just two Montessori classrooms, with a total of 33 children, so roughly 16 per group; Montessori classrooms are expect to have 30 to 35 children and in Dr. Montessori's descriptions, they often had 50 or more. Each Head Start classroom included only 4-year-olds, not the full 3-year age grouping. Each

was in its first year of existence. Each also had teachers with minimal training of just 8 weeks; in contrast, the AMI training course for primary teachers lasts 9 months. In the Miller study, a consultant rated programs for fidelity, and the Montessori classrooms scored 6.5 on a 10-point scale (with 10 being very high). The Karnes Montessori program study was subject to the same problems regarding limited ages and teacher training, and children worked for just 30 minutes per day with the Montessori materials rather than the expected 3 hours for 3- and 4-year-olds, and 6 hours for 5-year-olds. In sum, both Head Start Montessori studies involved lower fidelity programs and did not show immediate effects. Still, both showed some Montessori program advantage over time (Karnes et al. 1983; Miller & Bizzell, 1983, 1984; Miller & Dyer, 1975).

In both studies, children had less than a year of mediocre-quality Montessori at age 4, yet some positive outcomes were obtained for Montessori children relative to children in other types of preschool Head Start programs and these advantages lasted as far out as high school, when the studies terminated. For example, in the study by Karnes and colleagues (1983; Illinois), fewer Montessori children dropped out of school or were retained a grade. In the Miller (Kentucky) study, the Montessori boys (in particular) had higher standardized test scores than the children from the comparison Head Start programs (such as conventional preschool and Bereiter-Engleman and Darcy, school programs that were in vogue at the time). Although the results were reasonably positive across these two studies conducted in different states, caution must be exercised because of several shortcomings in the studies.

One problem with these two Great Society program studies is that very few classrooms were involved. Because of this, one cannot tease apart individual teacher effects from program effects. Perhaps the one or two Montessori teachers whose classrooms were sampled in one study were superb teachers, and in another study the Montessori teachers were poor ones. Respectively positive and negative findings would result, with an effect of teacher quality misattributed to an effect of program. In conventional education, quality of teacher interaction is the main predictor of child outcomes (Early et al., 2007; Pianta, Hamre, & Allen, 2012). Teachers' ability to sensitively respond to students' needs is also vital for Montessori education, and variation in teacher quality could have a meaningful impact when few classrooms were sampled.

Another issue that is true of these studies and many others is that the quality of implementation of the Montessori philosophy and materials was poor. There is no litmus test for calling a school a Montessori school. Even if one uses an accredited school, the different Montessori organizations have very different accreditation criteria, with some adhering more closely to Dr. Montessori's methods than others. Researchers often have not known how to determine whether a program adheres sufficiently to the principles and curriculum to be considered a good example of Montessori,

and instead they tend to trust that if a school calls itself Montessori, then it is a good place to test whether Montessori education matters for outcomes. In this book, I describe Montessori education as conveyed in Dr. Montessori's writings and in the training courses of the AMI. Although most Montessori schools surely support many of these principles, implementations vary widely. (Variation in Montessori schools is discussed in chapters 11 and 12.)

Another problem in these and many other Montessori outcome studies is that the numbers of children involved was small. Because of these problems and others, conclusions about the impact of Montessori from existing research usually must be very tentative. The right study, using randomly assigned children, a large sample size, many teachers, an excellent Montessori implementation, a long time span, and a variety of outcome measures is yet to be done, although some headway has occurred since the first edition (described in chapter 11). A different approach, taken in the next nine chapters, is to evaluate evidence for component aspects of Montessori education and their support in research.

Chapter Summary

Conventional schools have not fared well owing to the fact that the models of the child and school on which they are built—the empty vessel in the factory—fit poorly with how humans learn. The solutions Americans have devised to fix the problems in our schools repeatedly fail because they do not change these fundamental models. The educational system should instead draw on scientific study of how children learn. Taking such an approach clearly points to the value of revising these fundamental models.

Dr. Maria Montessori took just such an approach in the early 20th century, and the importance of her insights is reflected in their similarity to educational principles generated by modern psychological research. This book discusses nine of Dr. Montessori's major insights on how people learn and develop more optimally. Other authors might have arrived at a different nine: It is clearly not an exhaustive list of Dr. Montessori's insights. The insights discussed here are well supported by modern psychological research and have clear implications for more optimal ways of educating children.

2 }

The Impact of Movement on Learning and Cognition

> One of the greatest mistakes of our day is to think of movement by itself, as something apart from the higher functions. . . . Mental development must be connected with movement and be dependent on it. It is vital that educational theory and practice should become informed by this idea.
>
> —Maria Montessori *(1967a/1995, pp. 141–42)*

Movement and learning are perpetually entwined in Montessori education. Beginning in the home or day care, infants sleep on floor beds instead of cribs, so they can move around an entire room to explore and get objects. In Primary classrooms, children move to wash tables and trace Sandpaper Letters, to put large wooden map pieces in place as they learn their names, and to play scales and then compose music on Musical Bells. Older children carry out verbal commands written on cards, both to develop semantic precision and to experience what a verb is. They place colored symbol cards next to words to designate parts of speech. Countable squares and cubes illustrate mathematical concepts: A child can see, feel, and manually experience why 3^3 equals 27. Other mathematics materials work through the child's hand to show how the same formula for area can apply to a regular and an irregular shape. The possible examples are endless: In Montessori classrooms, learning is accomplished through movement.

In contrast, in conventional classrooms most learning is accomplished through listening and reading, reciting and writing. Children spend much of the day seated at desks, taking in lecture information, practicing written exercises, or transitioning between class topics. Except for the symbolic translation involved in writing, their learning is rarely connected to their body movement. For example, children tend to learn what a verb is by reading sentences and finding the verb, not by enacting the verb. They usually learn how to cube numbers by watching the teacher write a cubing problem on the board, then writing out problems themselves, rather than by making cubes and taking them apart. In conventional schooling, bodily movement

is limited and consists largely of writing numbers and letters that abstractly represent the concepts being learned. Today, some teachers in conventional schools incorporate hands-on exercises, which is positive. Yet the exercises are add-ons to an essentially lecture-and-recite-based system and are rarely integrated with other work across subject areas.

The conventional classroom's lack of movement fits the Lockean model of the child, in which learning occurs because the child takes in new information and commits it to memory. Behaviorists believed that the child does this because he or she is rewarded (with stars or good grades) for doing so and/or or punished (with demerits or low grades) for not doing so. Behaviorists were not concerned with what goes on inside of the child's mind, only with the outcome: proper recitation on an exam. Movement is not important to learning in this view. In fact, it is easier to pour things into empty vessels or to write on blank slates if they are still.

Conventional education's absence of movement is also convenient for a factory model, because all children do a single lesson in concert. If factory-based education relied on hands-on materials through which children move to learn, it would require one set of such materials for each child. This would be prohibitively expensive and impractical for storage of the materials. Providing children with several textbooks, into each of which many concepts can be packed and then read about in unison, is far more convenient. The factory and empty-vessel models seem to preclude any sizable portion of school learning occurring through movement.

Dr. Montessori saw the stationary child as problematic, because she believed movement and thought were very closely tied. Movement is integral to the educational program she developed. Recent psychological research and theorizing support Dr. Montessori's idea, with many theorists now claiming that cognition is profitably viewed as embodied (Barsalou, 2002; Lakoff & Johnson, 1999; Shapiro, 2011). "Embodied cognition" covers many bases, from the idea that we think in metaphors reflecting how our bodies are constructed and function (Lakoff & Johnson, 1999) to the view that organisms are dynamic systems that develop largely in response to—in adaptation to—their environment (Thelen, 2001).

In this chapter, I describe research supporting the close interconnection of bodily movement with development, thinking, and learning, and how movement is involved in Montessori education. I begin with basic developmental processes and research that shows how development and movement are closely entwined.

Movement and Basic Developmental Processes

> Until now, almost all educators have thought of movement and the muscular system as aids to respiration, or to circulation, or as a means for building up physical strength. But in our new conception

> the view is taken that movement has great importance in mental development itself, provided that the action which occurs *is connected with the mental activity going on*. . . . Watching a child makes it obvious that the development of his mind comes about through his movements. . . . Mind and movement are parts of the same entity.
>
> — Maria Montessori *(1967a/1995, p. 142, italics in original)*

In this section I discuss research suggesting the importance of movement to very basic developmental processes in infancy, ending with a discussion of Dr. Montessori's ideas about infant movement and about the Practical Life activities in Infant-Toddler and Primary classrooms.

In a classic work published in 1963, Richard Held and Alan Hein tested the effect of self-directed movement on a very basic developmental process: vision. They studied this with kittens because for kittens, as for humans, crucial visual development occurs in the months after birth. Ten pairs of kittens, one a leader and one a follower, were reared in the dark except for 3 hours each day, when they were placed in a normally lit room. While in this room, the leader kitten had attached to its body a harness and cart that pulled the follower kitten around. This set-up allowed the leader to actively explore the environment, guided by vision, while the follower kitten was passively pulled through the same environment. Although the follower had the same visual experience of moving through the environment, it was not actively engaged in the exploration. After three months, the kittens' vision was tested, and the findings suggested that active movement guided by one's vision was crucial to normal visual development. Whereas the leader kittens responded to such events as looming objects and apparent drop-offs, the follower kittens did not show evidence of understanding the possible impact of these environmental features. This classic study set the stage for a wealth of research on the effect of movement on the development of human babies. Learning to move is increasingly recognized as a key development. Children must learn to plan each movement, and successive motor accomplishments accompany cascades of psychological developments (Adolph & Robinson, 2015). That the brain and movement are so closely entwined should perhaps not be surprising. Doidge (2015), in pointing out that plants lack brains because they lack movement, refers to Ascidiacea (the simple sea squirt), an organism that has a brain until it plants itself in a set spot where it will spend the rest of its days—whereupon, no longer needing a brain, it eats it (Llinas, 2001, p. 15). The basic insight regarding the connection between the brain or mind and movement is fundamental to Montessori education and has been entirely lacking in conventional education systems. In this chapter, I first consider an earlier developmental movement, grasping, before moving to the topic of crawling in human babies.