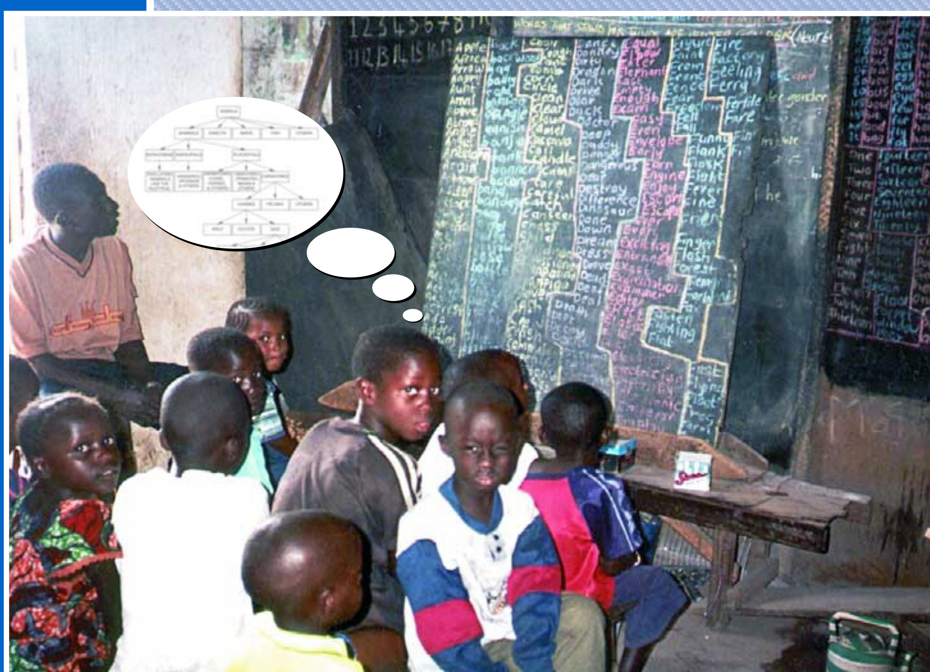
THE WORLD BANK

DIRECTIONS IN DEVELOPMENT

Efficient Learning for the Poor

Insights from the Frontier of Cognitive Neuroscience

HELEN ABADZI



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Overview

Donor initiatives in support of primary education have resulted in large enrollment increases in low-income countries. But the conditions of some classrooms can stretch the limits of human information processing. Many students are malnourished and lack textbooks or the help of literate parents. Overwhelmed teachers may work with just the few most capable students and discourage or fail many others for whom the Education for All initiative was developed. Not surprisingly, learning outcomes in low-income countries are often disappointing, dropout rates are significant, and students may leave school functionally illiterate. The Independent Evaluation Group of the World Bank has documented such evidence in several countries.

These outcomes put at risk the large investments made in the social sectors in hopes of alleviating poverty through human capital improvements. Governments need advice on how to teach students in circumstances that rarely existed until the 1990s. Cognitive psychology and neuroscience offer a framework for policy advice on improving poor students' learning. The research is evolving and has limitations. In some areas it has concrete and counterintuitive implications, whereas in others it has little to offer or corroborates common sense. This body of research is most valuable for the early years of schooling, when dropout and repetition rates are often high.

Research points to the following seven pillars that support basic skills and efficient learning for the poor. Some are old staples of development efforts, whereas others are relatively new or have received insufficient attention in the past. The findings show how an understanding of human memory and thought can lead to new approaches in solving difficult problems. They link outcomes with time and methods used in classroom, health and nutrition, teacher cognition, and school management.

1. Supporting Children's Brain Development for Efficient Learning

Malnutrition, parasitic diseases, limited stimulation, and a host of other challenges affect brain development and learning efficiency. Students whose health is burdened in these ways often drop out early. Addressing the issues provides a strong rationale for early childhood development and preschool programs. Primary school children should also get eyeglasses, deworming, and essential nutrients. In many low-income countries, school health interventions have been difficult to sustain. To get school health inputs, well-conceived and lasting collaboration between health and education ministries is critical as well as reliance on civil society institutions.

2. Using Every Moment of the Available Instructional Time

Governments pay for a human and material infrastructure to teach children during a specific number of hours or days (for example, 200 days or 1,000 hours per year). However, research shows the need for consistent reinforcement of learning and demonstrates the loss that occurs during long breaks from school. Even with existing patterns of schooling, time is rarely used consistently in support of learning activities. The amount of class time that students are engaged in learning (time on task) is perhaps the most important quality variable. It is conceptually easy to grasp, measurable, and has a demonstrable impact on outcomes. Governments may take actions to reduce school closings, teacher absenteeism and tardiness, and improve use of class time through better monitoring, agreements with teacher unions, and training specifically for making class time more productive.

3. Ensuring That All Have Textbooks to Take Home

Instructional time is used much more effectively when students have their own textbooks rather than copying from the blackboard or taking notes. Extensive contact with textbooks is needed not only for acquisition of fluent reading skills but for study of more complex material in the later grades. It is important that children be allowed to take books home, rather than accessing them only in classrooms. Supplementary books and inexpensive primary-school editions are needed in local languages when the language of instruction differs. Policies should support the continuous and well-managed procurement, local printing, and efficient distribution of textbooks.

4. Learning Fluent Reading and Calculation in Grades 1–2

Reading is a cornerstone for subsequent skills, and it relies fundamentally on how human memory works. The short-term memory holds only a few items for a very brief period of time. To comprehend a sentence, children must be able to decode it in about 12 seconds. The research that links reading to comprehension has profound implications for education, particularly in low-income environments. It leads to a *quantitative model of reading efficiency that has a simple and transparent monitoring indicator*. To understand lengthy texts, students must be able to read fluently at about one word per second (about 45–60 words per minute) and with about 95 percent accuracy. Across Europe, this level is often achieved by the end of grade 1 or by the end of grade 2 at the latest; but it appears to be reached much later, if at all, in many low-income environments. Yet there is reason to believe that these levels of achievement are easily within reach in low-resource environments as well. Early reading fluency is particularly important for students at risk of early dropout; this is because automatized skills are not normally forgotten, and therefore literate dropouts may later improve text comprehension. To prevent students from falling behind early on, activities that directly teach reading and math deserve priority in grades 1–2. Most class time in these grades might be devoted to reading and math. Countries might be advised to adapt curricula, plan for supervision, and train teachers to achieve the very important reading fluency goal. After this goal is achieved, instruction must switch to comprehension and higher cognitive skills that rely on fast reading and calculations.

5. Teaching Basic Skills to Young Students in Their Mother Tongue

Children's developmental window of opportunity for rapid language learning fades at about the time they enter school. Thereafter they need hundreds of hours of *interactive* language instruction and speech samples to mentally compute grammatical patterns. In resource-poor environments, crowding and minimal instructional time can reduce interaction with the teacher, which puts students studying in a foreign language at a permanent disadvantage. Students perform much better if they learn fluent reading and basic concepts in their mother tongues. This is particularly important when the official language of instruction has complex spelling rules (for example, English, French, and even Portuguese). Governments must be helped to overcome the logistical and political obstacles associated with teaching in local languages, including both teacher and parental resistance.

6. Basing Educator Training on a Few Well-Researched Learning Principles

Many cognitive issues conspire to make traditional teacher training ineffective in improving student achievement. People tend to imitate their own teachers when teaching, and behaviors shaped by role modeling may not be easily modifiable through academic training. Even effective training may have limited outcomes because material learned in a classroom or seminar room may not be easily recalled in another location. Furthermore, teacher training content tends to be theoretical and abstract, and delivered through lectures and notes. The challenge is to transmit clear, simple, doable advice to teachers, administrators, and supervisors, who often themselves have limited education. Such advice might include using class time efficiently, giving students opportunities to contemplate and practice the information given, giving interesting or frequently changing activities to maintain attention, and presenting challenging but achievable tasks to maximize the likelihood of student response. Lengthy lecturing to immobile and silent students is inefficient because without further elaboration the material may be forgotten. Teachers also need practical classroom management skills to handle large classes when materials are scarce, including grouping techniques and cooperative learning. More efficient training may involve role modeling and be conducted through multimedia presentations.

7. Ensuring Effective Teacher Incentives, Goals, and Oversight

Research underlines the importance of intrinsic incentives and immediate feedback for sustained performance, and clear responsibilities for accountability. Therefore, effective school operation may depend largely on regular supervision and two-way feedback. But various links of the supervision chain are often broken, leaving supervisors with few resources and little desire to visit schools regularly. Creative incentive structures are needed to encourage teachers, principals, and supervisors to do their job and ensure that school time is used for teaching. In some countries, communities have proven effective in monitoring school activities and in others they have not been. More efforts must be made to help communities carry out this task. One way to improve oversight might be for communities to monitor whether students become fluent readers in grades 1–2 and whether they can do basic math calculations.

"Trickling Up": Investing More in the Lower Grades

In resource-scarce environments, children rarely catch up after they fall behind. Failure to learn fluent reading and math skills in grades 1–2 *creates inefficiencies that reverberate all through the educational system,* up to the university years. Such failure translates into dropout, grade repetition, and a need for extra resources. If resources were focused on the lower grades, their effects would "trickle up" as children get promoted to the upper grades. Students in grades 1–2 are likely to perform better if they have more time on task, smaller classes, and more experienced teachers. Educating marginalized and vulnerable children may have higher unit costs, but the increased investment in the lower grades will result in savings from repetition, dropout, and time wastage.

Furthermore, students who acquire basic skills early on are more likely to maintain them if they leave primary school prematurely. Thus, it may *be possible to achieve basic skills for all.* Rather than focus on increasing the number of graduates, governments might focus on efficiency; that is, getting the *largest possible number of literate school leavers*.

Guidance from Neurocognitive Research on Frequently Asked Questions

Busy staff and policymakers may benefit from reading just the learning insights and policy implication sections of each chapter as well as Chapter 14 on incentives. Inspectors and supervisors of schools may find Chapters 8–13 pertinent. Below are questions that have been raised in evaluation documents or in discussions with donors and government staff:

- In the course of your work you visit schools and enter some classrooms. What signs should you look for to know if these schools deliver quality education? (See p. 63.)
- While visiting a teachers' workshop you hear that teachers should stop "frontal teaching," should implement "student-centered learning," or should give students a variety of activities. How sound is this advice? (See p. 74.)
- During a school visit a teacher tells you that children can't read well because they are poor and malnourished. Could she be right? (See p. 42.)
- If children learn to decipher letters and words and then drop out, are they likely to read in real life later on? (See p. 38.)
- If half the students cannot read in a country by the end of grade 2, is that disappointing or excellent? Do students need four years to become literate in low-income countries? (See p. 37.)
- Why are achievement tests typically given just to higher grades? What is appropriate for lower grades? (See p. 97, 101, 136.)
- Is it necessary to have one textbook per child or will one textbook per 2–3 children be enough? (See p. 91.)
- If a country cannot afford enough schools or teachers to implement Education for All, is it worth reducing class time per student to put more students into school? Will most still learn basic skills? (See p. 82.)
- My son entered a French immersion program and in just a few weeks he could speak some French. Now there is a movement to teach poor students in Francophone Africa through mother-tongue instruction. Why should we deprive them of the immersion opportunity that middle-class children get? (See p. 52.)
- What are the pros and cons of copying from the blackboard in class? (See p. 66, 185.)
- Is it bad for children to memorize information? (See p. 59, 65, 182.)
- Is it good or bad for children in class to repeat after the teacher or answer questions all together? (See p. 65, 184.)
- Are inquiry-based methods the most efficient means to teach science in lower-income countries? (See p. 77.)

- Julius Nyerere once said that education was too theoretical and not practical enough. What instructional features are needed to make it more practical? (See p. 167.)
- What is the use of learning to read in a maternal language if few books have been printed in that language? (See p. 39.)
- Should the donor community advise governments to adopt mother-tongue instruction whenever possible, or should it merely respect their cultural and political choices? (See p. 51.)
- Multigrade teaching is frequently considered a cost-effective means to teach children in remote rural schools. What are the most important prerequisites for successful implementation? (See p. 109–110.)
- In the project you are managing, large-scale, inservice training of ministry staff is planned for institutional strengthening. How should training be provided so as to maximize the probability that staff will later practice what they have been exposed to? (See p. 129, 194–196.)
- You are going to a workshop and you want to remember and put to use as much as possible from it. What can you do? (See p. 193–196.)

Acronyms

ADEA	Association for the Development of Education in Africa
AIDS	acquired immunodeficiency syndrome
ARDE	Annual Report of Development Effectiveness
CERI	Centre for Educational Research and Innovation
DFID	Department for International Development (United Kingdom)
ERDC	Educational Research and Development Center
EFA	Education for All
fMRI	functional magnetic resonance imaging
GDP	gross domestic product
IEG	Independent Evaluation Group of the World Bank (formerly OED)
IMF	International Monetary Fund
IQ	intelligence quotient
ISCED	International Standard Classification of Education
MET	magnetoencephalography
MLA	Monitoring Learning Achievement
MIT	Massachusetts Institute of Technology
MSI	magnetic source imaging
NGO	nongovernmental organization
NMDA	N-methyl-D-aspartate receptor
OECD	Organization for Economic Cooperation and Development
OED	Operations Evaluation Department (now Independent Evaluation Group—IEG)
OREALC	Oficina Regional de Educación para América Latina y el Caribe
PASEC	Programme d'analyse des systèmes éducatifs
PET	positron emission tomography
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
PPAR	Project Performance Assessment Reviews
REM	rapid eye movement (sleep stage)
SACMEQ	Consortium for Monitoring Educational Quality
TIMSS	Trends in International Mathematics and Science Study
UNESCO	United Nations Educational and Scientific Council
UIS	UNESCO Institute of Statistics
USAID	United States Agency for International Development

PART I

Cognitive Research on Basic Skills

1 The Pedagogy of Poverty

"A variety of 'inputs' apparently are tossed into the classroom, activated in some mysterious way, and out pops pupil achievement (the 'output')." Fuller and Snyder 1991

Arguably, the least effective strategy to educate the poor in Madagascar is through the medium of the French language. The country has only one national language, Malagasy, which has been written for centuries. Yet, in response to middle-class demand, the government in 1993 decreed that French would be the language of instruction after grade 2. In 2001, the World Bank's Independent Evaluation Group (IEG)[1] found high dropout rates in rural schools, in addition to graduating students who were unable to read fluently in either Malagasy or French. The government acknowledges the problem, but has found it hard to implement a solution that serves the poor as well as the middle class.

Responding to the letter of a 10-year-old student in the Brazilian northeast who kept failing because of inadequate instruction, the government launched in 1996 the "Call to Action" initiative. Reforms included a four-year cycle during which children would not repeat a grade, curricula with emphasis on discovery, and enormous amounts of instructional materials and staff training. However, tests showed limited achievement, and an IEG mission in 2002 found that in poor areas many students still read haltingly in grade 4. In classes, children were often engaged in fun and creative activities while surrounded by books they could not read. In this middle-income country, many students were dropping out, still functionally illiterate after 4–5 years of school.

The above examples illustrate some of the puzzling outcomes and dilemmas encountered in efforts to finance quality education for the poor.

Educating the poor is a large-scale effort in which the World Bank and the donor community have focused since the 1980s. Its apex has been the Education for All initiative (EFA; see Box 1.1) that promotes primary school completion for all children by 2015. EFA supports achievement of the Millennium Development Goals that aim at reducing poverty by improving the planet's human capital and resources.

The result of EFA has been impressive, including enrollment increases in poor countries over a few decades that sometimes surpass the long-term trends of industrialized countries (see, for example, Figure 1.1).

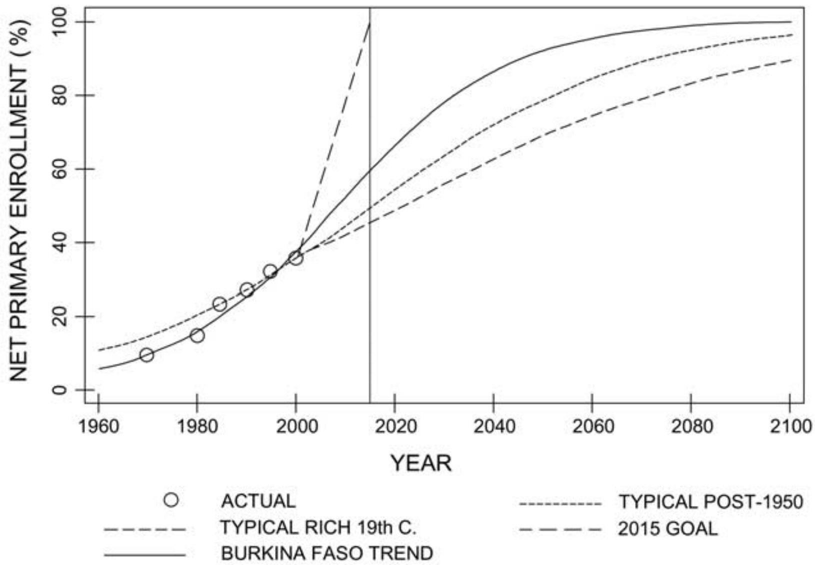
The sixth goal of the EFA initiative focuses on education of sufficient quality to provide nearly all children with basic skills. However, learning among the poorer children who enroll in school remains elusive. The percentages of those who attain mastery criteria, however set by various countries, are often in the single digits. For example, in Pakistan, only 34 percent of 11–12 year olds who completed primary school could read with comprehension, and fewer than 20 percent could write a simple letter. In 22 states of India, the average grade 4 achievement level was 32 percent in mathematics and science, compared to a pass mark of 35 percent and most children must reach grade 5 to be able to read the newspaper. In Zambia only 25 percent of grade 6 pupils reached the minimum-performance

Box 1.1. The "Education for All" Goals

1. Expand and improve comprehensive early childhood care and education, especially for the most vulnerable and disadvantaged children.
2. Ensure that by 2015 all children—particularly girls, children in difficult circumstances, and those belonging to ethnic minorities—have access to complete, free, and compulsory primary education of good quality
3. Ensure that the learning needs of all young people and adults are met through equitable access.
4. Achieve a 50 percent improvement in levels of adult literacy by 2015, especially for women, and equitable access to basic and continuing education for all adults.
5. Eliminate gender disparities in primary and secondary education by 2015, with a focus on ensuring that girls have full and equal access to basic education of good quality.
6. Improve all aspects of the quality of education so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy, and essential life skills.

Source: EFA Global Monitoring Report 2002.

Figure 1.1. Burkina Faso, a Poor Country with Large Enrollment Increases by Historical Standards



Source: Clemens and Moss 2004.

benchmark, and only 2 percent reached the desirable performance level, while in Namibia only about 7.6 percent of grade 6 students perform satisfactorily.[2] Analyses of internationally comparable assessments of learning achievement in math, reading, and science show that most developing countries rank very far behind OECD countries.[3] (See examples in Table 1.1.)

Clearly donors and governments envisaged that investments made to enroll large numbers of poor children in school would lead to learning, but learning outcomes are often insufficient for life-long productivity. Why are the results so different from expectations?

In some respects, the poor performance is a consequence of the enrollment success. Unprecedented numbers of students in countries like Uganda and Kenya have entered public schools that traditionally taught only those who could perform. The curricula and teaching methods that function with middle- or lower-middle-class students may be inappropriate for poorer students. The result is classes in remote rural areas or periurban areas that are crowded and may lack the benefits of textbooks, trained teachers, or literate parents. Observations repeatedly show ineffective practices in the schools of the poor—practices which have been on occasion called "the pedagogy of poverty."[4] Along with funding, therefore, clear knowledge

Table 1.1. Quantitative versus Qualitative Indicators of School Participation

Country	*Cohort*	*% ever enrolled (ages 6–14)*	*% reached grade 5*	*% achieved minimum mastery*	*% enrolled and achieved minimum mastery*
		Study: SACMEQ (1995) grade 6 reading test			
Malawi	100	91	31	7	8
Mauritius	100	99	98	52	53
Namibia	100	97	74	19	20
Tanzania	100	87	70	18	21
		Study: PIRLS (2001) grade 4 reading test			
Colombia	100	98	60	27	28
Morocco	100	99	77	59	60
		Study: PASEC (initial 1990s) grade 5 reading test			
Burkina Faso	100	35	25	21	60
Cameroon	100	88	45	33	38
Côte d'Ivoire	100	65	45	38	58
Papua New Guinea	100	48	32	21	44
Madagascar	100	78	31	20	26
Senegal	100	48	42	25	52
Togo	100	82	49	40	49
		Local test (2002)			
Uruguay	100	100	98	66	66
		Local test (2000)			
Yemen	100	73	51	10	19

Sources: EFA Global Monitoring Report 2005; Administración Nacional de Educación Pública—Uruguay 2003; Educational Research and Development Center—Republic of Yemen, 2000.

Note: PASEC = Programme d'analyse des systèmes éducatifs; PIRLS = Progress in International Reading Literacy Study; SACMEQ = Consortium for Monitoring Educational Quality.

and advice are needed on how to help students learn under difficult and inefficient circumstances.[5]

Well-informed advice has been hard to find. Educators are practitioners and are not systematically trained on how or why certain things work.[6] Without an explanatory framework it is hard to evaluate the effectiveness of educational interventions in low-income countries, decide on relevant indicators, and expect a certain magnitude of effect. Reference points are lacking, such as what tasks poor students should be able to perform in different grades if taught well. The lack of reference points is compounded by a lack of test scores in low-income countries to demonstrate performance changes over time.

Institutions like the World Bank seek answers from the economic knowledge base. The vast literature on the economics of education has treated education largely as a means of increasing earnings. In the classical Mincerian wage earnings function, earnings depend only on years of schooling and work experience.[7] This theory, developed in industrial countries of the mid-twentieth century, leads to an implicit assumption that learning in a classroom will somehow happen if inputs are provided. It has thus been reasonable to agree on an "access first" policy of lowering unit costs enough to enable all children in low-income countries to enroll in schools. How children will learn has been considered a "black box," a detail to be improved once school management is strengthened.

Economics cannot provide all the answers, so staff working in the sector often look to best-practice examples or to their academic training for policy advice. Some reflect on their own or their children's experiences. However, the potential for good policies from these sources is limited because employees of international organizations were often exceptional students who attended good schools. For example, some may believe that if they could learn through the English language medium, then everyone else can. Love of French may have influenced language of instruction policies in Francophone Africa. A policy of cutting down instruction time by 40 percent to fit more children in African schools reflected the practice of sending young Scandinavian children to school for fewer hours. A belief that improving management indicators would improve educational quality formed the basis of projects in Brazil that failed. Cost-saving policies on instructional materials have deprived students of textbooks to take home and the means to practice reading. And the consequent low achievement has led to the widespread conclusion that children in developing countries need 4–6 years of schooling to become literate.[8] These often implicit and unexplored beliefs may influence policy dialogue and financing decisions.

Industrialized countries spend more resources for disadvantaged children than for middle-class children. Extras may include remedial reading, bilingual education, small classes, longer school hours, feeding, and psychological support. However, some donor strategy papers give the impression that it is possible to educate inexpensively countries full of disadvantaged children who may not even know the official language. The low percentages of students showing mastery of various tests (Table 1.1) suggest that those who learn under these circumstances are mainly the better-off or the gifted.

The results obtained thus far from educating the poor risk disappointing donors and reducing investments to education in favor of infrastructure investments that might have greater poverty alleviation potential.[9] Practical means to improve school efficiency are urgently needed.

Neurocognitive Research: The Key to the Black Box

What is the minimum amount of educational inputs that will teach basic skills to the majority of students in low-income countries rather than merely the gifted? Answers to this seemingly impossible question may be deduced from some branches of "hard" science.

Research on learning and memory has provided insights for over a century into how people process information. Such research includes neuropsychological insights on how the brain works, cognitive psychology on how people think, and learning studies on how organisms modify their behavior. An understanding of what the brain was designed to do through evolution also gives insights on which tasks are easier to learn and also helps explain some social psychology phenomena. Since the 1990s, this domain of knowledge has been greatly enriched by brain imaging techniques that help visualize the areas of the brain activated when various tasks are carried out. The convergence has led to a field often called cognitive neuroscience that has applications in artificial intelligence and decision theory. One attractive aspect of this research is its trans-national character. Human brains process information in much the same way, and similarities may be more important than individual or cultural differences. Such unifying principles may point to common solutions for educating disadvantaged children efficiently and may be applicable from preschool to the university.

Neurocognitive research is an exciting frontier, and industrialized countries have formed programs to transform findings into educational applications.[10]

Figure 1.2. Fulani-Speaking Girls in Rural Niger

What investments in time and money are needed to teach them fluent French so that they can then learn basic skills?

Source: Author.

However, staff working on the education of developing countries have had little contact with this domain of knowledge. Much important research dates from about 1995 onwards, and many mid-career professionals do not know it. The publications are not easy reading; they often have awkward sentences and terminology incomprehensible to laymen. Cognitive psychology is rarely taught outside psychology departments, and its relevance to the education of the poor is not obvious even to its professors. One must integrate discrete pieces of these disciplines and think hard to find pertinent applications. Memory is extremely complex, with multiple levels and partly overlaying aspects. Furthermore, new research appears daily, changing some premises. But it is possible to create order from a morass of classroom variables, to form actionable priorities, and to give valid and cost-effective advice to countries.

This publication offers educators the findings of contemporary research pertinent to the education of the poor as well as a line of reasoning for making quality-oriented decisions. It arose in the Independent Evaluation Group (IEG), a semi-autonomous entity of the World Bank. Over a period of 10 years, the author carried out many Project Performance Assessment Reviews (PPARs). These revealed similar problems in very different countries, but there was little underlying rationale to compare outcomes against expectations. For three years, the author searched for emerging research daily on the Internet for explanations and solutions, and contacted the researchers, who were usually happy to assist. (Their names are in the list of acknowledgements.) Danish trust funds made it possible to consult with neuropsychologists and obtain research summaries on various topics.

The document links problems identified most often during field visits to relevant cognitive and neuropsychological research. A line of reasoning develops through school health, memory, and cognition in Part I, extends to educational resources in Part II, and to human resource issues in Part III. The main text minimizes the use of terminology, but endnotes and the annex give details for those with more specialist interests.

The content has limitations. Insight from this body of research is most valuable for the early years and developing minds—the EFA clientele. Advice is less clear for the intermediate years and more advanced skills, though there are useful implications for the training of adults. On some topics like reading the implications are clear, but for others like challenge and motivation, the research only offers hints. Cognitive psychology findings are older and better validated than those of neuropsychology; however, the research subjects were often U.S. college students who probably have more practice in complex skills than poorer populations. Also, the relative importance of variables and magnitude of effects are hard to gauge, particularly when multiple factors are considered that have not been tried out together. The search for overarching principles plays down individual differences. Notwithstanding all the caveats and shortcomings, this publication shows how cognitive research on the education of low-income students can be summarized in 2006.

2
Health, Nutrition, and Cognitive Processing

Learning Essentials

Malnutrition and ill health may significantly damage the cognitive processing ability of poor students. Students whose processing capacity is affected by ill health and malnutrition may require more hours of instruction to learn various skills. Early childhood education, along with health and micronutrient supplementation for school children, may prove critical in achieving Education for All in low-income countries or areas. These very effective interventions require close and sustained collaboration between ministries of education and health. Means must be found to facilitate their execution.

To the Western visitor, students in low-income countries seem very small for their age. They also tend to be quiet and well behaved. While such classrooms may appear to be conveniently manageable, all is not well with many of these children.

To function, neurons require energy that is obtained when the body metabolizes glucose and delivers it through the blood to the neurons along with oxygen. The various stages of the glucose-to energy conversion require oxygen, vitamins, minerals, and micronutrients. Nerve cells are partly made of essential fatty acids that are obtained from food, so these substances are essential for brain development and learning. Not surprisingly, well-fed and healthy nerves are required for efficient brain function and learning. This is why early nutritional and health interventions are needed for the poor. As the Education for All initiative brings to school the most vulnerable populations, the chances increase that some students will have neurological damage that affects information processing capacity. Some types of damage can be mitigated and others cannot. Some have larger effects than others, but multiple sources of damage make cognitive deficits add up. The literature on these subjects is vast; only highlights leading to school health interventions are discussed below.

Health and Nutritional Obstacles to Learning

The poor are at risk for cognitive processing problems from multiple sources that interact with each other. As a result these multiple factors, perhaps 40 percent of children younger than 5 years in low-income countries may have stunted growth.[1] Such factors are likely to affect the neural systems mediating attention and memory.

Early risks for diminished cognitive processing include difficult births, low birth weight,[2] and exposure to toxins, such as arsenic and lead, which affect the ability to plan. Home violence[3] seems to wire the brain to react in certain ways and interferes with consolidation of certain types of memories (Chapter 4). Serious infections may result in lower measured intelligence quotient (IQ) and impaired visual-motor functions.[4] Contaminated water has considerable health consequences for children.[5] Repeated *intestinal infections* (such as giardia) particularly in the first two years of life may reduce cognitive ability, as dehydration caused by diarrhea results in reduced blood flow to the brains of young children. Parasites such as hookworm, schistosomiasis,[6] and malaria may cause chronic anemia. Chronic *worm infestations,* sometimes due to poor school sanitation, drain children's nutritional resources, resulting in impaired memory and reasoning, and a loss in measured IQ.[7] Healthier children are more likely to go to school, and treatments reduce absenteeism.[8] A one standard deviation increase in child health increases achievement test scores by about one-third of a

Box 2.1. Health and School Attendance

A rigorously studied Mexican program paid poor mothers a small sum if they kept their children in school and got them immunized. A large randomized trial, published in 2001, showed that the children who participated were healthier and stayed in school longer. Healthier children are more likely to go to school.

Providing poor students with free uniforms or a simple porridge breakfast substantially increased attendance in Kenya. On the other hand, giving students drugs to treat the intestinal worms that infect more than a quarter of the world's population was more cost-effective, with a price tag of only US$3.50 for each additional year of schooling achieved.

Sources: Dugger 2004; Kremer and Miguel 2001.

standard deviation of that score—the equivalent of spending eight more months in school, which implies a benefit-cost ratio of at least three.[9]

Physical and mental health problems may push students into the special education category. Though there are few surveys, the schools of the poor may have a number of students with borderline retardation or reading and learning disabilities. For example, between 11–18 percent of children in Central America have disabilities, but less than 10 percent of them receive educational services.[10] Even students who are only physically handicapped may be involved in fewer activities and may have fewer skills. The challenge is to adapt curricula and instruction to meet special needs in low-income countries.

Overall, food insecurity has specific developmental consequences for children.[11] The diets of young children in developing countries often are of low quality in terms of energy and nutrient concentrations; as a result, multiple nutrient deficiencies are common.

Some examples of nutrient deficiencies and their effects are offered below.

Essential fatty acids (found in animal fats, fish oil, and plants such as evening primrose) are required for brain development. Young infants should receive these through breastfeeding. However, the very poor may eat very few fats and rely on a diet of a single staple, such as millet. Children who rarely or never eat meat, or live away from coastal areas where fish is available, may be at risk for learning and reading difficulties as well as delays in motor development, attention deficit, and behavior problems.[12] A study undertaken in Northern Ireland using a daily nutritional supplement with an appropriate fatty acid balance showed significant reading improvements.[13]

Micronutrient malnutrition is a pervasive and debilitating problem and it is more severe when children are small and younger and the mothers less educated.[14] Iodine deficiency in areas of heavy rainfall (as in Bangladesh) is associated with reduced intelligence; even moderate forms of iodine deficiency lead to the loss of 10 to 15 IQ points.[15] Zinc deficiency can also be significant.[16] Low iron and the resulting anemia adversely affect attention[17] and cognitive ability, resulting in significant productivity loss.[18] Anemic women make double the errors in a memory task than an iron-sufficient group and take longer to do tasks.[19] They also lack nutrients to transmit to their children during pregnancy. Iron deficiency significantly affects brain development by age 2; it is widespread, particularly among girls.

Protein-energy malnutrition (common in Africa) also affects girls' cognitive functions disproportionately, including the ability to learn categories, process and structure information, learn and react to social and environmental cues, and identify and solve relevant problems. In Mali, for example, 38 percent of children were found to have moderate or severe stunting, while 65 percent had moderate or severe anemia.[20] These multiple sources of malnutrition may also constrict the growth of the head size during rapid brain growth and affect intelligence (Annex I-E).[21]

Malnourished children are sick more often, are susceptible to infections, and are more likely to drop out of school.[22] Several studies using longitudinal data and special features to identify causal effects have found a link between poor pre-school nutrition and school achievement.[23] In one study, Jamaican children who were malnourished or had stunted growth scored 10 points less in an IQ test than children of normal weight and height.[24] In another study, malnourished children from Mauritius scored 15.3 IQ points less compared to controls by age 11, and the nutritional status was linked to a considerably higher incidence of aggressive behaviors and hyperactivity.[25]

Studies find both delayed school initiation and fewer grades completed for malnourished children, as well as negative consequences for performance on cognitive tests as adults.[26] Malnourished children enter school later and perform more poorly on cognitive achievement tests. Malnutrition in the first six months can be reversed, but the second year of life is critical due to rapid brain development.[27] The effects of malnutrition cannot be mitigated after age 2 or 3 and cannot be compensated by improved nutrition later. The challenge is to reduce early malnutrition, preserve cognitive processing power, and also reduce later antisocial and aggressive behavior.[28]

School feeding programs may not mitigate early malnutrition but in principle are highly desirable, partly because they attract school children who are chronically hungry.[29] Food during school hours, particularly breakfast, may improve concentration, particularly in chronically deprived children who have limited excess stores of energy. Malnourished children in Jamaica who had not eaten breakfast performed less well than controls on working-memory measures (digit span), problem solving, and fluency.[30] However, feeding programs cost a lot, may create economic distortions in local markets if food is imported, and have a large potential for mismanagement. More limited interventions, such as providing fruit or highly nutritious biscuits and milk, proved affordable in countries like the Dominican Republic.

Several donor-financed projects have attempted nutritional interventions such as micronutrients, deworming, and vitamin A with encouraging results. Eyeglasses may also be provided. In principle, reaching children in schools with essential treatments is efficient, given the frequent public-health difficulties of bringing the population to centers for health interventions. It is feasible to distribute to schools pharmaceuticals that need to be administered once or twice a year such as albendazol for deworming and vitamin A. Other interventions, however, such as iron require daily or weekly administrations and are harder to program. As a result, the logistics and management of various interventions become complex. Problems have been known to arise with pharmaceutical procurement, worker absenteeism, poor communication of health messages, and inadequate coordination between health and education ministries.[31] Thus, beneficial interventions can be compromised by imperfect delivery mechanisms.

Developmental Delays and the Importance of Preschool

With fewer opportunities to learn skills useful in school, low-income entrants to grade 1 may lag behind better-off children in terms of psychomotor development, reasoning, complex grammar, and vocabulary. Poor parents do not talk to their children as much as middle-class parents, and when they do, they use simpler phrases with limited vocabulary. In the United States, a socioeconomic gap in vocabulary is often established by age 3 that affects reading skills and is hard to remedy (Table 2.1, Figure 2.1).[32]

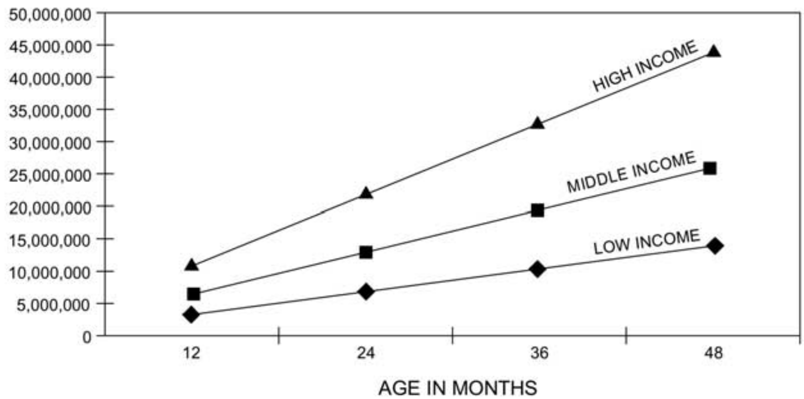
The poorer children may simply lack the cognitive networks and prior knowledge to which they can attach school-related information. Teachers may pay little attention to immature children, who may fall further behind. Grades 1–2 in effect screen out many such children in low-income countries, who drop out of school illiterate by grade 3. Parents in response may send children to school when they consider them ready, often at ages 8–10.

Table 2.1. Amount of Parental Interaction with Children in the United States

	Type of Home		
Interactions	*Professional*	*Working Class*	*Welfare*
Interacting with a child—minutes per hour	42	27	12
Utterances to the child per hour	487	301	178
Number of words a child hears per hour	2,150	1,250	620
Quality of language	Richer nouns, modifiers, past-tense verbs		More frequent imperatives, prohibitions

Source: Hart and Risley 1995.

Figure 2.1. Cumulative Number of Words Addressed to Children According to Income Level



Source: Hart and Risley 1995.

Overage enrollments may be to some extent due to the cognitive delays caused by long-term malnutrition and ill health.

Stimulation results in new brain tissue and nerve connections and thus may help children who suffer nutritional deficits early in life. The principle behind early childhood development (ECD) and preschool education is to reach children as early as possible with nutrition, health interventions, and stimulation, so that they can later benefit from primary education. In recent years, several programs have been implemented in low- to middle-income developing countries. Examples include the U.S. Head Start program, Bolivia's Integrated Child Development Project, Colombia's Community Child Care and Nutrition Project, Indonesia's Early Child Development Project, and India's Integrated Child Development Project. World Bank projects have also helped train caregivers and educate parents. Examples include Mexico's Initial Education Project, Chile's Parent and Children Program, Uganda's Nutrition and Early Childhood Development Project, Kenya's Early Childhood Development Project, and the Philippines' Early Childhood Development Project. Studies have been carried out in countries such as Bolivia, Jamaica, Guatemala, the Philippines, and the United States.[33]

Studies overall suggest positive effects from the various interventions on children's health, nutritional status, and psychosocial development.

These effects may result in higher achievement test scores and graduation rates and in lower grade repetition, special education needs, crime rates, and delinquency. For example, a 20-year study in a rural area of Guatemala combined data on early biological indicators, graduated parameters of social structure, and preschool cognitive assessments into a risk scale, and analyzed the data in relation to primary school grade attainment and adolescent psychoeducational test performance. Performance declined with the number of risk factors to which a subject was exposed. However, brain stimulation was also an important factor, and primary education buffered the effects of early risk. Children at high risk who stayed in school performed significantly better than those with similar levels of risk who completed fewer than four years of primary school.[34] Similarly, the Abecedarian project in the United States showed that early childhood education has a powerful influence on poor children that lasts into young adulthood, affecting things like reading and mathematics skills and even the timing of childbearing. Children who received high-quality day care consistently outperformed their peers who did not on both cognitive and academic tests, and also were more likely to attend college or hold high-skill jobs.[35]

Implementation challenges. Early childhood donor interventions tend to be complex operations that disburse small amounts of money to large numbers of users and need considerable monitoring. Countries must provide standards, information, and staff training, but many have not yet developed the institutions needed for such interventions. The programs also need strong national support to become financially sustainable as well as incentives to civil society and local governments for the development of new providers, such as mothers in home-based programs (as in Colombia and Bolivia).[36] This strategy implies cost sharing by communities through a mixture of block and matching grants. With limited institutional strength, outcomes in lower-income countries are more subtle and modest than would be expected.

Thus, despite efforts to finance early childhood development and kindergartens in many countries, the vast majority of poor children remain unserved. A child in sub-Saharan Africa can expect to receive just 0.3 years of pre-primary schooling, compared to 1.6 years in Latin America and the Caribbean and 2.3 years in North America and Western Europe.[37] Yet in the United States, investments in low-income children's preschool have a high payoff. The average cost per child may be US$6,000–12,000, but the savings in terms of later services have been estimated at about US$30,000–120,000.[38]

The unmet need for language complexity. Despite successes, preschool programs often fail to close the gap between the poor and those who are better off. One reason may be that the effectiveness of activities is unknown.

Though curricula are based on developmental concepts, it is unclear how they are implemented. Children are often observed playing with educational toys and interacting among themselves, but these activities may not be what the poor need. According to some researchers and practitioners, the critical skill to develop during preschool years is language vocabulary and complexity. Children learn language interactively, which means that an adult must interact with them individually rather than just within a group.[39] To prepare for reading a language with complex spelling (such as English or Urdu) they need exercises to recognize sound segments (called phonological awareness exercises). Children will benefit from training to recognize compound words, delete initial and final phonemes, and understand rhymes. However, many day care workers are themselves poor and have a limited knowledge of language. The challenge is to train day care workers of limited education to scaffold children's language through simple games, pairing them up for increased communication rather than keeping them in a group, and talk to each child individually.[40]

Preschool education is clearly desirable, but what can be done when students arrive in primary schools without this training? Some middle-income countries, such as Uruguay, offer compensatory programs (Box 2.2).

Policy Implications

Interventions in health and nutrition are necessary, starting even before birth if possible. Because selective feeding is expensive, an integrated approach is needed to ameliorate nutrition problems. Part of this approach is providing information to parents who simply may not know that their children must eat before school.

Early childhood development and education interventions may help overcome developmental delays. During the school years, poor children may benefit from longer school days and extra help with school work. They should receive school health inputs such as eyeglasses and micronutrient supplements along with school feeding if possible. The difficulties of these operations must be dealt with cooperatively between the health and education sectors. Donor procurement procedures must be harmonized. Health intervention costs have not been included in the Education for All financing simulations, but the pharmaceuticals are not expensive. More important are the management problems that must be overcome if interventions are to be implemented in a sustainable fashion.

Research needs. Although school health and nutritional issues have been studied extensively, there is little information on the interactions of nutritional, developmental, and educational variables. Many issues must be clarified, such as the relative importance of instructional time versus stunting-wasting effects on reading fluency, how much extra instruction is needed to offset the cognitive deficits created by health issues, and additional

Box 2.2. Full-Time Schools: Special Attention for Low-Income Students

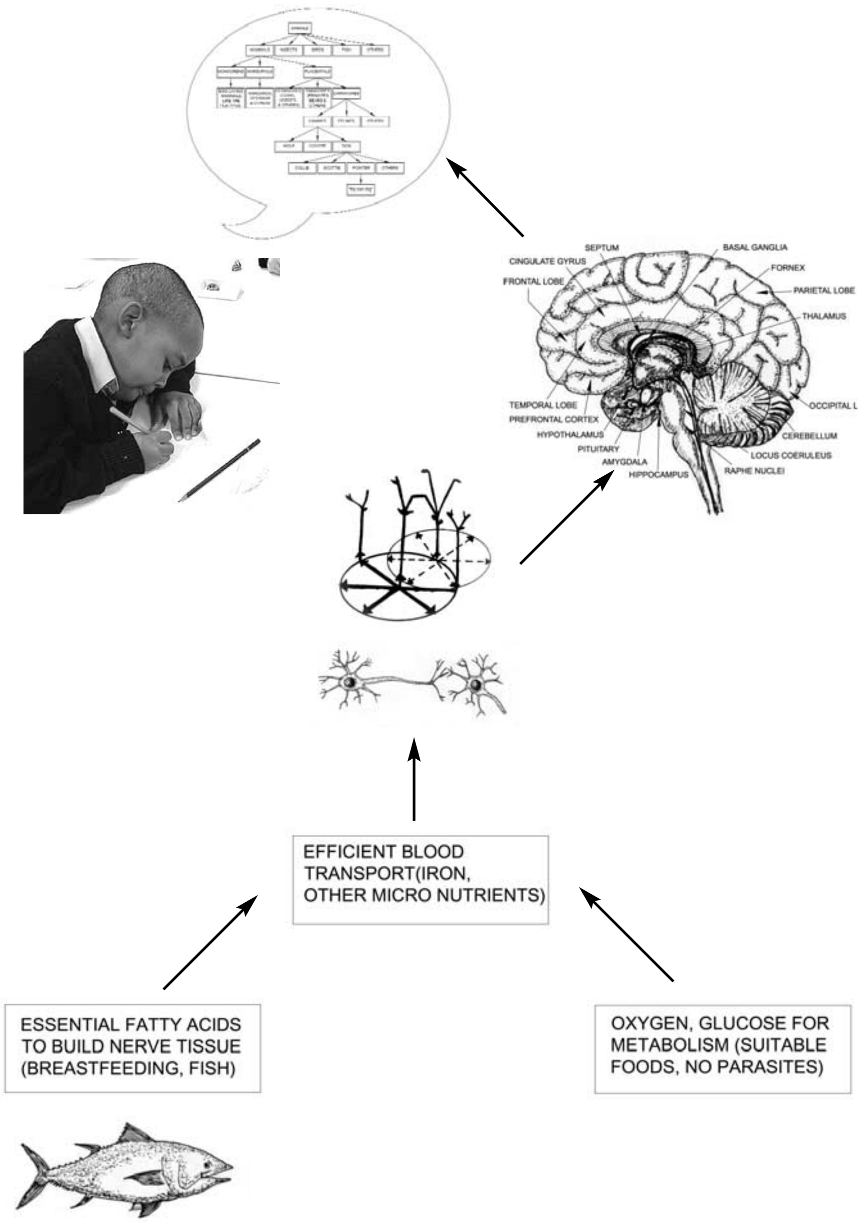
Limited learning among the poor is not just a problem of low-income countries. The young generation in many industrialized or middle income countries disproportionately comes from poorer families that have more children. To maintain their high-level human capital, countries like Uruguay and Brazil must adequately budget for and educate large numbers of poorer students. One means is to keep students in school most of the day.

In the full-time schools of Uruguay, the day lasts 7.5 hours and includes two or three meals usually cooked on site. Students carry out the regular school curricula in the morning and work on various projects in groups in the afternoon. In the early afternoon, children play games like chess, checkers, ludo, and sports. Later they form groups of mixed ages and carry out workshops on expression, mathematics, sciences, computer use, language, and social studies. There is no homework time, and the long hours do not permit much formal homework in the evening. By contrast, the secondary full-time schools of Pernambuco (Brazil) give students an hour of supervised homework.

Sources: OED 2005c; MECAEP 2002.

costs to educate poor students in low-income countries. Most important, research must determine through randomized experiments what intervention combinations will be most cost effective in various countries.

Figure 2.2. Biological Needs for Learning: From Nutrition to Cognitive Networks



Source: Author.

3
Nervous System Linkages with School Performance

> ***Learning Essentials***
>
> To attain high-level skills, learners must first master component tasks in small bits. To increase performance speed and accuracy, practice and feedback for error correction are necessary. Only with manageble tasks and feedback can learners progress to more complex skills.

The origins of memory are lost in the mists of DNA and subatomic particles. At the level it can be traced in 2006, the smallest units influencing memory are proteins with complex names that direct nerve communication and set millions of nerve cells to connect momentarily like flashing light bulbs in intricate patterns. It is not clear how people can have relatively stable memories over 100 years while the body's tissues are rebuilt every few months. Memory is very strange—and the more we learn about it, the stranger it seems. It evolved to help organisms find food and avoid harm, so it is influenced by factors such as sex hormones, sleep, physical effort, laughter, chewing gum, and aromas of lavender and rosemary.

Teaching is a function widely used by animals, even by some species of ants.[1] Schools essentially must create two skill levels: (1) mastery of certain procedures to the point where they become *unconscious and automatic*, and (2) the application of the procedures to structure information into conceptual knowledge that is used *consciously and deliberately*. To acquire these skills, children must learn in a prescribed period of time topics that they do not need immediately and would not normally seek on their own. The acquisition process is not necessarily pleasant, and many children would prefer other activities. Furthermore, some may be unable to do the tasks at the ages that curricula prescribe. It is not surprising, therefore, that teaching can be difficult. In many countries children who cannot perform simply drop out. To carry out the EFA initiative, however, means must be found to teach primary school subject matter to nearly everyone. Neuropsychology provides some useful ideas on how to proceed.

The rules of learning that govern high-level reasoning can be detected at the level of neuron connections. If we understand this level, we can roughly predict how much learning various educational interventions are likely to leave in students' minds.[2] Connections among neurons create momentary patterns (spatiotemporal patterns; Annex I-B). A process that is analogous to "Darwinian" selection uses feedback and error correction to determine what patterns work best. Successful patterns expand and recruit other neurons, unsuccessful ones die out. Thus, the most useful memories prevail, as summarized below:

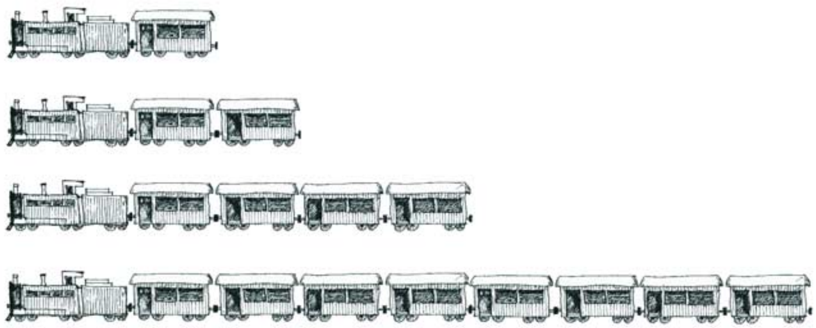
- We recognize *faster* items we saw recently or see often.
- We build *more* knowledge on what we see often.
- Rarely used concepts take a long time to recall.
- Behaviors executed enough times tend to become *automatized.*[3]
- Behaviors executed rarely may be *forgotten* (lost or overwritten by other spatiotemporal patterns).

These "micro" principles work on a "macro" level as well. The mind assembles small units in larger arrangements. Larger units are learned well enough to be produced automatically, and then bolted into ever larger arrangements. The tendency to create ever-bigger chunks through automaticity seems to rule all learning. It includes motor skills (such as dance steps or surgical procedures), language learning that progresses from phrases into sentences, and perception of single letters that are instantly assembled into words. Practice is needed, and it compiles a halting sequence of steps into a fluent performance. Small facts are learned and then integrated into higher-order thinking, like railroad cars that are hitched together to form long trains (Figure 3.1). Certain areas of the brain regulate this automatization (Annex I-C).

Instruction is most effective if small steps are used to build high-level skills. Without sufficient practice, the learner must always build answers out of small units rather than larger assemblies.[4] Feedback and correction are an indispensable part of the skill-building process. Neurons in several brain structures appear to code prediction errors in relation to rewards, behavioral reactions, punishments, and external stimuli.[5] Learning occurs when the outcome of an action differs from the desired or predicted outcome.

Better-off children who get much learning practice and parental feedback "compile" the simple skills quickly and early in life and then go on to fluency in reading, languages, or math. Poorer children get less home practice and must automatize the basic steps in school. Educators often do

Figure 3.1. Learning Skills by Automizing Small Units and Assembling them Into Larger Units



Source: Author.

not realize this principle and may not budget for the time and materials needed for all students to become fluent in low-level skills. Limited practice and feedback are partly responsible for the achievement gap between the middle-class and the poor. Therefore, intervention is needed at grade 1 or earlier (if possible) to increase the fluency of poor children.

Policy Implications

Educational decisions are often made with middle-class children in mind, who are ready for complex tasks earlier than the poor. "Whole-word" reading methods, "new math" that rejects rote learning of multiplication tables, and long lectures are examples of instruction that assume an early ability to deal with complexity (Chapter 9). Effective schools, particularly those catering to the poor, must offer students time to learn well the small units that are required before higher functions like analysis and comprehension are achieved.

4
Memory and Basic Skills Acquisition

Learning Essentials

Information directed at students faces a stringent competition for survival. The capacity and duration of short-term memory (about 7 items for about 12 seconds) determines comprehension and governs the acquisition of academic knowledge, including reading, math, and foreign languages. Better students tend to have longer and more efficient short-term (working) memory, while malnourished students tend to have shorter working memory. Once past working memory, the information does not get saved instantly like a computer saves text. It gets consolidated over a period of hours or several days, and during this period it is vulnerable to forgetting. Information gets reconsolidated every time it is recalled, and new information can be integrated with recalled memories.

Memory is a very complex system and the subject of research in multiple disciplines. Researchers have tested various aspects of remembering and forgetting since the 1880s and have developed hypothetical mechanisms and theories on how these processes operate. The advent of brain imaging in the 1990s made it possible to look for these cognitive mechanisms in the brain and locate the areas in which they reside. Biochemistry has also given a much more refined picture of how memory happens at the molecular level. The cognitive mechanisms proposed in the twentieth century still remain largely valid and are useful in discussing educational interventions. This chapter presents the memory basics necessary to facilitate educational policy development. It touches upon attention, the structure of memory, and the intricacies of consolidation.[1] More information is provided in Annex I-D.

Knowledge Intake: Attention Span and Prospects for Improving It

Attention is an interplay of zooming in on detail and stepping back to survey the big picture. It focuses an organism's resources on an important task, much as a spotlight does. But putting the spotlight on one item means that items outside this narrow area are not noticed, even when changes are big. And, if we do not pay attention, events are not registered in memory. *People can only pay attention to limited amount of information at the same time* (Annex II-A). A child's attention span starts out brief, but increases steadily through the early school years and adolescence. It improves particularly after age 10.[2] A rough empirical estimate is that attention lasts 1–3 minutes for every year of a child's age;[3] but children tend to focus their attention longer on activities they choose over those imposed by adults, so precise measurements are difficult.[4] Events like videogames and television cartoons that have immediate feedback and fast-moving designs may capture attention for longer periods.[5]

A class activity that lasts longer than the average attention span for a given age is likely to lose many students. Their attention may come and go, but they will have lost at least part of the message. The challenge for children of all ages is maintaining attention on material that is not of direct, immediate interest and ignoring distractions. Teachers can change activities frequently, make them more interesting and less arbitrary, signal when students must pay special attention, or give students responsibilities that require sustained attention. Interesting pictures, emotionally engaging material, a lively tone of voice, or just getting up and stretching can help in this regard. It also helps to warn students that an item must be attended to, as people pay attention better when prepared.[6] Information gathered through an innovative experience sampling method shows the importance of such techniques (Box 4.1).

Maintaining attention is particularly important in low-income countries, since most children cannot afford private tutors to review material they have missed. But it is unknown how attention develops among the poor children. The neurological mechanisms that control it may be vulnerable to malnutrition and delays, as is the case of working memory (see below). If so, briefer attention spans and attention deficits may be one more limitation that poorer children face.

The Peculiarities of Memory: Eternal as Well as Fleeting

Very roughly, memory can be divided into *short-term memory* (temporary storage before processing) and *long-term memory* (relatively permanent

Box 4.1. How Much Attention Do Students Pay in Class? It Depends on the Subject

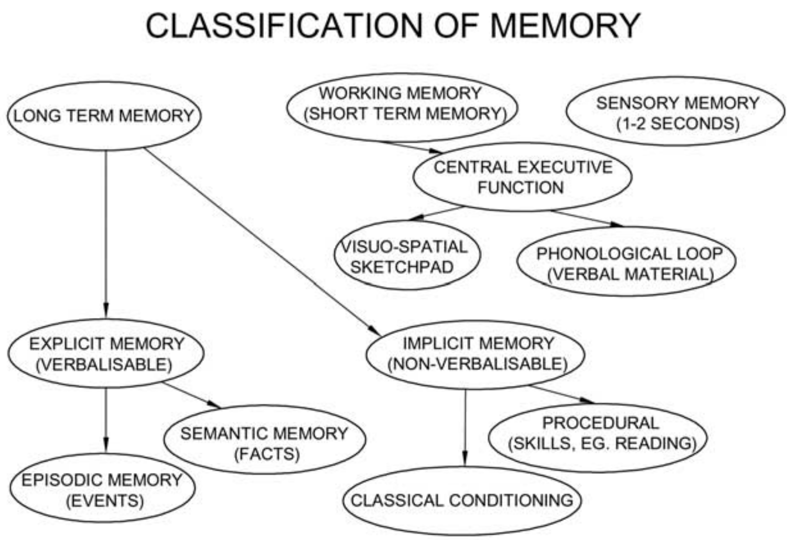
An innovative study on attention and instruction gave students in the United States watches that beeped at random and asked them to write what they were doing when it beeped. Overall, students reported engagement in lessons only 55.4 percent of the time; 62 percent in grade 6 but only 47 percent in grade 12. Disengagement increased with age and absorption in other activities. Students paid attention 63 percent of the time during math, 55 percent during reading, 74 percent during laboratories, and 70 percent during group work; boys engaged in class 21 percent more than girls, and blacks overall engaged 29 percent less time than non-blacks. Relevant and challenging materials held the attention more than boring materials. Teacher-centered methods that were directed at the entire class rather than at individuals got less engagement. Courses such as mathematics that demand prior knowledge forced students to be engaged more often than courses where prior knowledge is not needed

Source: Yair 2000.

storage). Various types of information are processed in somewhat different ways (Figure 4.1):

- *Implicit* memory refers to items that cannot be retrieved consciously but are activated as part of particular skills or actions. Implicit memory reflects learning a procedure or pattern, which might be difficult to explicitly verbalize or consciously reflect upon (such as tying a shoe, riding a bike, taking the road to school, forming letters with a pen, role-modeling adults' behavior patterns). These skills become to a considerable extent automatic and are executed with little or any thought.[7] Because we are unaware of many such activities, this type of learning tends to get underestimated and receives little attention in formal education.
- *Explicit* (or declarative) memory supports acquisition of factual knowledge that can be verbalized. Explicit memory is often divided into *episodic memory* and *semantic memory*:
  - *Episodic* memory concerns the storage and recall of specific events or episodes occurring in a particular place or at a particular time, such as comments made by classmates in school.
  - *Semantic* memory comprises our encyclopedic knowledge about the world that is not associated with a specific time or location. This is mainly the type of memory that schools are expected to produce.

Figure 4.1. Structure and Types of Human Memory



Source: Illustration by Christian Gerlach, Learning Lab Denmark.

These types of memory work seamlessly together and constitute our knowledge base. People learn much information by mere exposure to some event, not through a conscious effort. For example, we recall people's voices or entire songs we heard repeatedly without making an effort to memorize them. Other concepts are too complex to be learned with a single exposure, or they involve coordination among many areas of the brain (like writing or riding a bike). These require deliberate practice to master. The challenge is how to achieve mastery with the least time, effort, and expenditure.

Working Memory: A Concept Critical for Effective Education

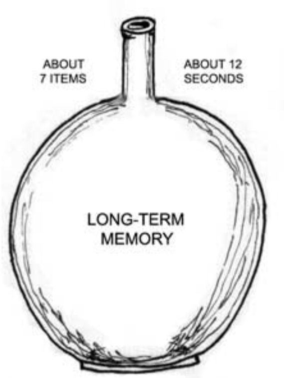
We can pay attention to and process only a small amount of the information that registers in our senses. To be registered in permanent memory, the information must first go through the *short-term memory* (a system more frequently referred to as *working memory)*. Working memory holds the information that one is currently thinking of. The mechanism is indispensable for decision-making, and the greater its capacity, the more efficiently people can use the data they receive in their everyday lives.

Working memory holds and decides what to do with items that come from the outside world or are retrieved from the long-term memory. It sorts them in categories like a busy librarian sorting books into shelves. Working memory consists of *a central executive mechanism* and two slave systems referred to as the *phonological loop* and the *visuospatial sketchpad* (Figure 4.1). The phonological loop holds information in a speech-like code (for example, a telephone number one hears). The duration and capacity of its storage are exceedingly limited. There is space for only about seven items, and they can stay in the phonological loop only for about 12 seconds. The visuospatial sketchpad holds visual or spatial information, such as a picture that was just seen. It only holds about four items, which is why people tend to have poor memories of scenes they see briefly. Information may be exchanged between the verbal and visuospatial systems through recoding. This is what happens when we see a telephone number and convert it into words that we rehearse in our minds while looking for a telephone. The central executive mechanism keeps the information alive through repetitions and prevents irrelevant material and distractions from interfering.

Why Is Working Memory So Important for School Work?

To understand whatever we perceive, we need to keep it in our minds long enough to evaluate it. But the brain allots very little time. Short-term memory (working memory) works a bit like a sponge moving about 12 seconds behind people's thoughts and wiping the slate (Figure 4.2). It is as if information tries to get into a big bottle through a very narrow opening.

Figure 4.2. Memory Capacity: An Exceedingly Large Bottle With a Narrow Opening



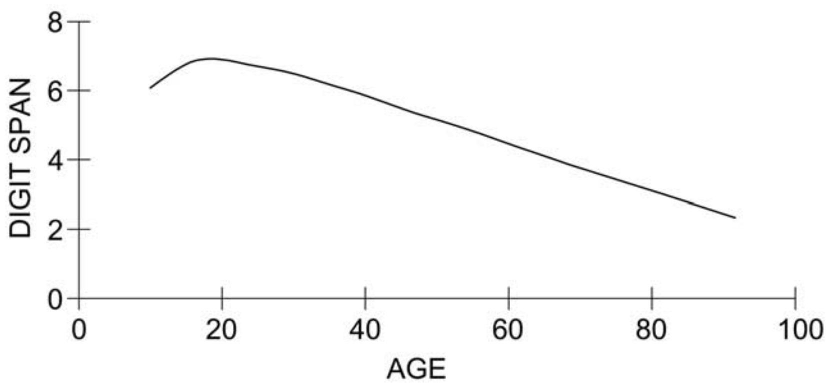
Source: Author.

For more material to survive and be processed, tricks are needed. People rehearse or repeat the contents of the verbal buffer, such as repeating a phone number until they get to a telephone. The mind also combines small chunks of information into larger ones that pass through working memory as one piece, allowing accomplished readers to perceive words or sentences rather than merely letters. Because working memory holds little and empties fast, it is important to read and calculate fast. Even milliseconds can make a difference in learners' likelihood of understanding or remembering a concept.

Working memory capacity increases as children grow. Neural connections ("white matter") increase in the frontal lobes of the brain, and messages can be sent fast to various parts of the brain.[8] The phonological loop and visuospatial sketchpad do not communicate well in children up to age 4 or 5. But by age 6, children have the working memory components found in adults, and each component undergoes expansion with age through the early and middle school years to ages 16–19. Working memory capacity peaks around the age of 20 and then gradually declines (Figure 4.3).

Schooling lengthens working memory, and longer schooling is related to a larger capacity. Adults with higher education have significantly better working memory than those with fewer than 12 years of education,[9] and adult illiterates have shorter working memory than literate people.[10] *Better students tend to have working memory with longer holding and processing*

Figure 4.3. Best-Fit Relationship Between Working Memory and Age



Source: Li 2003.

Note: Working memory is measured in research as the number of digits one can repeat backwards and forwards.

capacity, providing a bit more time for comprehension; students with more limited working memory have lower performance. British research has found that at age 7, student performance in language and math is significantly associated with working memory scores, and, in particular, with performance on complex span tasks that rely on the capacity of the central executive. The strong link persisted in math and science at age 14, though not in language.[11] However, mere holding capacity is not sufficient; efficiency is also important. In real life, for example, one must hold in memory extra or borrowed digits while doing additions and subtractions on paper or store some words while working with equations. In the United States, this "active span" of working memory correlates highly with Scholastic Aptitude Test scores and reading comprehension and predicts problem-solving capacity.[12] In principle, working memory may improve through computerized exercises.[13]

Working memory development and poor children's school performance. Research in Jamaica measuring the number of digits a child could remember suggests that malnutrition is associated with reduced working memory capacity.[14] The more limited capacity may be due to limited home practice, delayed maturation of white matter in the brain,[15] the distracting effects of hunger, anxiety, or an interaction of these factors. Malnourished students fail more often in school work than better-off students (Chapter 2). If neural systems supporting working memory show delayed development, students may perform academically a year or two later than expected. Research is needed on the working memory capacity of the poor to help clarify curricular and instructional implications.

With a larger working memory capacity, children around age 12 can process more information.[16] By that age, they are also able to pay attention for longer periods and scan material more thoroughly[17] and have acquired learning strategies, such as maintenance rehearsal.[18] They may organize information into larger and more complex chunks and may process information faster.[19] Thus, children who have missed years of school may undergo *accelerated learning* and cover the curriculum of two years in one.[20] This feature may help teach out-of-school adolescents or children in post-conflict areas, such as Afghanistan.

How Information Learned in School Is Consolidated

Once information is processed by the working memory, consolidation starts. It is a biological process that occurs outside people's awareness and without additional training or exposure to the original learning event. Recently acquired information must be associated with past experiences, networks must be reorganized after new information intake, and then memories must be consolidated again. Certain memories are actively erased as new information comes in or trivial details are dropped. While a memory is being consolidated it is vulnerable to forgetting. Early on a memory may be clear but unstable and subject to being forgotten. Over time it may become less clear but more stable and resistant to interference from other memories.[21]

Memory research is evolving, and relatively little is known presently about consolidation (sometimes called memory modulation). Different types of memories are consolidated at different rates or perhaps through slightly different processes. For example, memories of fearful events are rapidly and permanently consolidated,[22] while others may need from 24 hours up to 30–45 days. Experiments on the learning of coordination-based skills (such as driving, playing a sport, learning a musical instrument, or performing a surgical procedure) reveal a consolidation process that lasts about six hours, after which the learned skill can be "edited" and improved. For this stage, sleep is important, particularly the last two hours of the night. Study subjects tested 24 hours after a finger-tapping lesson, and following a night's sleep, were found to have improved or enhanced memory from the previous day by 20 percent over subjects tested before sleep. Thus, new skills need six hours to be stabilized and become less vulnerable to competing information. Then they can be practiced again for improved performance. Consolidation efficiency depends to some extent on age and maturity of white matter in the brain. Young children learn and forget easily, as do older adults (Annex II-L).

Every time memories are recalled, they get reconsolidated. During recall, they become vulnerable again to modification, and sometimes new information may overwrite old information. However, the reconsolidation process makes it possible to connect new knowledge to older and enriching knowledge networks. And reconsolidation lasts a shorter time than consolidation of the original memories—perhaps two days rather than 45.[23]

Memory mechanisms reflect the evolutionary needs of organisms for surviving various hazards and thriving. Substances such as glucose, and the adrenal hormones epinephrine, norepinephrine, and cortisol, are released into the bloodstream during times of arousal, stress, and emotion. These substances enable people to remember events that are important rather than trivial.[24] The effect depends on an optimal amount of the substance (too much or too little is ineffective) and on a narrow timeframe, 30 minutes to two hours. Thus, the following variables affect consolidation:

- *Glucose consumption*. Consumption of slowly digesting carbohydrates increases memory consolidation. Because the effective dose range is rather narrow, too much glucose may impair rather than enhance cognitive functions. A chocolate bar is not suitable because fat stalls the energizing effects of glucose.[25] Preferable are fresh fruit, whole wheat foods, and legumes. Chewing gum tricks the body into believing that food is consumed and has been shown to improve recall of words by 24–36 percent (Box 4.2).

- *Emotional incidents (including humor)* can help people remember unrelated information as long as the two occur within a close timeframe. When something emotional happens, people get a jolt of adrenaline that helps them remember the moment more clearly, including events around that moment. An experiment showed that TV humor increased recall of material learned 30 minutes later. The results suggest that the window of opportunity for memory modulation in humans is between 20 and 40 minutes after learning and may improve recall by about 18 percent.[26] Similarly, students who learned a list of words and saw a video of gory dental surgery remembered on average 10 percent more of the words than those who saw a simple tooth-brushing video. It was also shown that students who received a dollar after learning a word list remembered the words better than those who got nothing, even a week after the words were presented.[27] These findings and the earlier behavioral research imply that students should be rewarded for performance once in a while rather than consistently, because a constant reward may stop being exciting.

Box 4.2. Chewing Gum Increases Recall of Words

Insulin mops up glucose in the bloodstream, and chewing causes the release of insulin, because the body is expecting food. Insulin receptors in the hippocampus may be involved in memory. Therefore, it has been hypothesized that chewing might improve long-term and working memory. In an experiment, one-third of 75 adults tested chewed gum during a 20-minute battery of memory and attention tests. One-third mimicked chewing movements, and the rest did not chew. Gum-chewers' scores were 24 percent higher than the controls' on tests of immediate word recall, and 36 percent higher on tests of delayed word recall. They were also more accurate on tests of spatial working memory. Chewing gum elevated heart rate significantly above that in the sham chewing and control conditions. This response may improve cognitive function due to increased delivery of blood to the brain. But attentional tasks, which might be described as assessing purer aspects of "concentration," were unaffected by chewing gum. Thus, chewing gum may improve performance in certain memory tasks. Nevertheless, teachers typically ask students to stop chewing gum when they enter the class.

Sources: Mamose et al. 1997, Farella et al. 1999, Kennedy and Scholey 2000.

- *Physical stress or arousal* shortly after learning can improve retention because exertion elevates adrenaline levels. In one experiment, young adults were asked to squeeze a hand dynamometer at maximum effort for 30 seconds. Then they were asked to exert a moderate amount of tension (25–50 percent of baseline maximum) during or after learning a word list. They were tested immediately and a few days later. Those who squeezed the dynamometer for 30 seconds before learning as well as during learning and recall remembered 10–15 percent more words at a later time than those who only squeezed it for one second prior to learning. It was also found that exertion induced before and during learning helps the body to learn better.[28]
- *Certain substances* alter the amounts of neurotrasmitters affecting nerve transmission; for example, drinking *sage tea* has modest effects on recall.[29] The smell of rosemary during training has been found to improve memory and alertness. Conversely, the smell of lavender reduces working memory efficiency and speed and impairs reaction times for attention and memory tasks.[30] Neurological research has produced drugs to improve consolidation and recall, partly to alleviate aging-related memory loss due to aging, but drugs to improve educational interventions are still under development. (Ampakines are promising compounds.) About two cups of *coffee* significantly improve working memory and attention by increasing activation in areas involved in these functions.[31]
- *Sleep* is necessary for consolidation. During sleep, newly acquired memories are transferred from the hippocampus to more permanent storage in the cortex.[32] Sleep protects memories against subsequent interference or decay and also appears to "recover" or restore memories.[33] Sleep also promotes higher-level types of learning, and facilitates mathematical insights and problem solving,[34] particularly after eight hours of rest.[35] Also the *circadian rhythms* affect memory, and knowledge is better consolidated when people study at the time when they are supposed to be awake rather than, say, late-night sessions.

Forgetting. Generally, people forget a fair amount of what they learn within a few days or months after learning it, and then the rate of forgetting levels off. The amount ultimately forgotten depends on how meaningful and well connected the text is to the existing body of knowledge; much material heard in a class is simply not well connected or important enough to survive. For example, about 50 percent of lists with unconnected words are forgotten within one hour, but well-connected bodies of knowledge may survive at about 60 percent rates of retention for 50 years (Annex II-B, II-G). The implication for school learning is that material must be practiced often and connected well to survive the advent of new items.[36] Students enrolled in schools that close for weeks on end or who attend rarely (as in rural Bangladesh) may not get sufficient exposure to consolidate material from one session to the next and keep forgetting what little they learn.

The research on physical exertion after learning suggests that *playgrounds* and physical education classes are more important than previously thought and not just because they enable children to let off pent-up energy. They foster consolidation of the previous hour's lesson. (A moderate amount of exercise works best, because exhaustion may interfere with consolidation.) Another implication is that practice of motor skills (from piano to vocational education and labor-intensive apprenticeships) might be recalled more easily if practiced in the evening before sleep. Furthermore, doing physical effort *after* study (such as agricultural work or jogging), exchanging jokes, or even watching thrillers on television (that are not too disturbing) may facilitate consolidation. The emotional events must be used in moderation, since extremes of arousal tend to have a negative effect on memory. But the practical magnitude of these effects in real life is unknown.

The interaction between the working memory that sorts material, and the consolidation mechanism that stabilizes it, creates some of the effects that students notice as they learn. Material presented at the end of a learning period is recalled more accurately since nothing else is presented for a while to interfere with consolidation. Cramming before exams may result in retaining sufficient material to pass a test the next day, but does not result in long-term retention, as some material is not consolidated sufficiently or

Box 4.3. Poor Students Forget More During End-of-Year Vacations

Meta-analyses of studies indicate that students forget during vacations some of what they learned. In the United States, student scores fall about 1/10 of a standard deviation during the summer, equivalent to losing about one month of work. All of the students lost math skills over the summer. More math content was lost than reading or language arts content. Low-income students showed a greater average loss in reading (2/10 of a standard deviation) compared to middle income students, who showed a modest gain. No systematic effects (gains or losses) were associated with either gender or race. Level of parental education also made a difference. The children of high school dropouts lost more during the summer than did children whose parents finished high school.

Source: Cooper et al. 1996.

faces interference by other items. (See primacy-recency effects and massed versus distributive practice in Annex II-B). It may be beneficial to take a break and have a positive emotional experience or engage in a sport (assuming that students can get back to studying afterwards). The tools and means to do homework (such as textbooks taken home) and reviewing notes before sleep[37] are important components in memory consolidation.

The emerging understanding of memory consolidation has implications for learning during and after school. School is, in effect, a race of learning and forgetting, a bit like a vessel full of water with small holes. As the day progresses, the pieces of information most likely to be retained are…

- presented in activities that maintain or attract children's attention
- repeated more often and overlearned or automatized
- connected to existing knowledge, the more the better
- presented in the beginning or end of a class
- learned in small chunks over several days or weeks
- perceived as somewhat distinct from others, but not unheard of
- presented within about 30 minutes of humorous or emotional events
- learned during or right after physical activity
- presented after consumption of food containing slow-digesting glucose
- reviewed while mostly still remembered
- reviewed in the evening before sleep (particularly motor skills)

The effect size of each variable may be modest and their relative weights have not been researched. But to some extent they must be additive and affect individuals and different cultures and contexts differently. Chapter 8 and Annex section II offer more explanations and practical applications.

Policy Implications

Knowing the memory basics would help decision makers in education predict more accurately how students are likely to perform under various conditions. This material should be included in the curricula of preservice and inservice training programs for teachers and administrators.

Research Needs

The processes of attention, working memory capacity, and consolidation are almost exclusively known from studies in industrialized countries. Learning more about the memory capacity of the poor in low-income countries may greatly enlighten the efforts to teach poor students basic skills.

5
Literacy Acquisition and the Biology of Reading

Learning Essentials

Learning to read involves "tricking" the brain into perceiving groups of letters as coherent words. To achieve this and to link the letters with sounds, explicit practice is needed. The more complex the spelling of a language, the more practice is needed. Though many bright children can learn to recognize whole words, most learn reading more efficiently by starting with small units of one or two letters.

To understand a sentence, the mind must read it fast enough to capture it within the time limit of the working memory. This means that children must read at least 45–60 words per minute to understand a passage. Fluency is required for analysis of texts. When the spelling rules are simple and instruction is sufficient, most children learn reading in their own language in 4–6 months. Reading in languages with complex spelling patterns, like English, Portuguese, Tamil, or Urdu takes longer to learn. If the neural circuits used in reading are functional, even poor and malnourished children should learn to decode and read fluently (though they may have difficulties in comprehension). Since many do not get extra practice at home they may require more teaching hours to become fluent. When large numbers of students are unable to read in grades 2 or higher, the likely reason is limited or inappropriate instruction rather than poverty and malnutrition.

The most striking finding of field visits by the World Bank's IEG has been children's widespread inability to read, even in advanced primary grades. Reading surveys in countries such as Guinea, Mali, India, and Peru show that in some areas most low-income first- and second-graders are unable to read.[1] Without this skill, students cannot learn from textbooks or respond reliably to standardized achievement tests. Most important, poorer children fall behind early on and usually cannot catch up. However, the consequences of the inability to read are not sufficiently appreciated.

Government officials seldom observe classes and may expect that the poor will master reading as easily as their own children, who get help at home. Usually, reading benchmarks or standards based on feasible practice do not exist, so some teachers may believe that children need three or four years to learn basic reading. Thus, they may be satisfied with limited student accomplishments and attribute reading deficiencies to poverty or malnutrition.

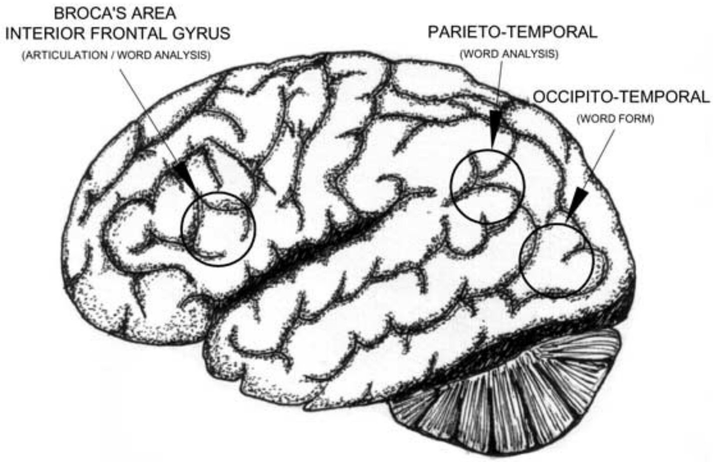
Reading has a large biological component whose role is critical in the earliest stages of literacy acquisition. This component needs to be better understood if children are to progress from deciphering letters to analyzing texts. The reading skill must be acquired because the brain is not genetically programmed for reading. Multiple circuits are involved, including those that partly control the processing of fast-moving objects.[2] The nervous system must become "programmed" for reading. Not all brains are prepared: some areas may not coordinate as expected and reading difficulties may result. The following prerequisites are involved in reading:

- neural circuits sufficiently mature to connect sounds to letter groups and word meanings[3]
- sufficient knowledge of the patterns of a language to perceive separate sounds, syllables, and words (phonological awareness)
- sufficient working memory available to understand a message (see Chapter 4)
- vocabulary knowledge for comprehension[4] and context knowledge for interpretation

To understand a sentence or a meaningful unit, people must hold it in their working memory long enough to examine it and make sense of it. However, working memory is very limited. The verbal buffer can only hold about seven items for about 12 seconds (Chapter 4).[5] In rough terms, this means that about seven words can be maintained for about 12 seconds. Since many sentences are of that length, people must be able to read a sentence in about 12 seconds to be functionally literate. *This frequency amounts very roughly to one word per 1–1.5 seconds, or 45–60 words per minute*. Unless people read at this speed, they cannot keep an entire sentence in memory; by the time they reach the end of a sentence, they have forgotten the beginning. To avoid cluttering the working memory with failed attempts, people must also read accurately. A 5 percent inaccuracy rate in reading is associated with comprehension test scores of only 75 percent.[6]

To get around the limited working-memory span, the brain has the tendency to create larger chunks of frequently occurring stimuli and then process these very fast and automatically. Thus, brain imaging studies show that both fast and slow-processing regions are involved in reading (Figure 5.1).[7]

Figure 5.1. Slow and Skilled Reading Areas



Source: Shaywitz 2003, pp. 78–82.

Two slower pathways are involved in *word articulation and analysis* (in the left parieto-temporal area and in the inferior frontal gyrus, near Broca's speech center). Beginning readers use these pathways to link letters to sounds and decode words. Involvement of the speech area creates the tendency to sound out a text subvocally in order to decode it. Though it is possible to read letter by letter, processing in these two areas challenges the limits of the working memory. Novice readers who make conscious decisions about letters can only read small amounts of text and may have to read a message repeatedly to understand its meaning.

Fluency is achieved when an *instant word recognition* pathway is activated (in the left occipito-temporal region). For this, *much practice is needed in pairing consistently sounds with groups of letters*.[8] A reader must analyze and correctly read a word several times before the pathway is activated. Then an exact neural model of that specific word is formed, reflecting its spelling, pronunciation, and meaning, and is permanently stored in the occipito-temporal system.[9] This region responds very rapidly to the word (in less that 150 milliseconds) and sees it as a pattern. This is how reading is automatized. The added advantage is that automatic behaviors are not easily forgotten. Therefore, *automatic readers do not normally lapse back into illiteracy.*

In principle, it is possible to learn fluent reading without knowing a language; many children learn to read sacred texts, such as Koranic Arabic, by monitoring sound frequencies.[10] However, it is much easier for someone who knows a language to read fluently in it. This is because people identify letters faster if they are inside words than if they stand by themselves (a phenomenon called "word superiority effect").[11] Also readers have the benefit of context and can guess words they may not read fully. Therefore, students may benefit from learning to read in their mother tongue or one that they know well, even if they will rarely read in that language later. Fluent reading in a language with simple spelling (such as Spanish or Tagalog) facilitates reading in a language with more complex spelling (such as English or French) when the same script is used.[12]

Once the automatic pathway is activated, reading speed rises fast, and comprehension may follow suit. With sufficient practice, the intermediate stages do not last long. Proficient readers read effortlessly and anticipate what kind of text will come on a page. Looking at the left side of a page (or right side for Arabic and Hebrew), peripheral vision records outlying material. More recently seen and more frequently used words are recognized faster, and errors are smoothed over without people noticing. So, people can make sense out of grossly misspelled words with missing letters.

The amount of practice required to activate the automatic pathway depends on the consistency between letters and sounds. Most languages in the world are spelled regularly. When taught the sound-letter correspondences in reasonably good schools, children read common words fluently and quite accurately by the end of grade 1. Languages with simple spelling tax the working memory less[13] and make it possible even for weaker students who rely on their slower reading pathways to make sense of the text. So, in the phonetically spelled European languages, middle-class children read basic text fluently before the end of grade 1 and may teach themselves to read in kindergarten. For example, Italian children learn the basics in about three months and master coding skills almost perfectly by the end of the first grade.[14] Greek children also have near-perfect reading accuracy by the end of grade 1, though length of words may slow reading speed down. When taught efficiently in languages with simple spelling, students progress at similar rates and show small individual differences (Figures 5.2(a) and (b)).

By contrast, in languages with complex spelling, rates of progress are slow, and individual differences are wide and persistent. Such languages require more practice for automaticity and also faster reading for timely comprehension. For example, a Portuguese-speaking child reading *os mesmos, a gente, bom dia* must understand the meaning at least partly and decide within milliseconds when to pronounce an *o* as *u, d* as *g,* or *t* as *ch.* A French-speaking child must make similar choices, but the choices are more consistent, and first graders learn French as fast as Greek children when taught through phonics. Spelling in Denmark and Norway is more complex, but students are typically able to "crack the code" by the end of

Figures 5.2(a) and (b): Performance at the End of Grade 1 in Very Common Words of Various European Languages

Fig 5.2a

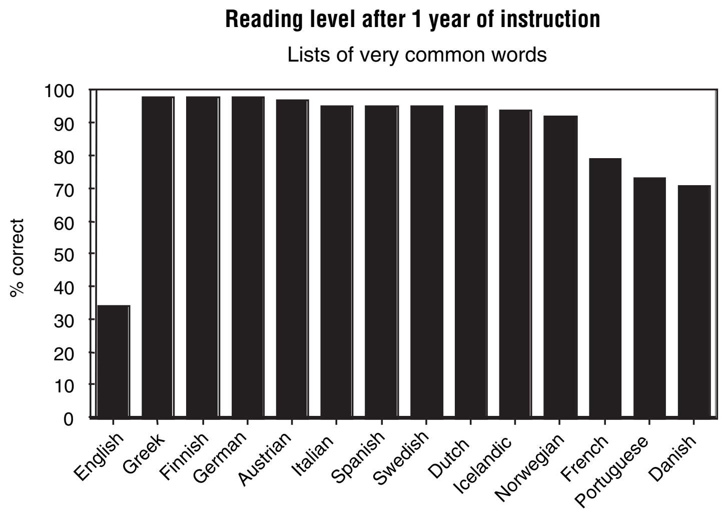
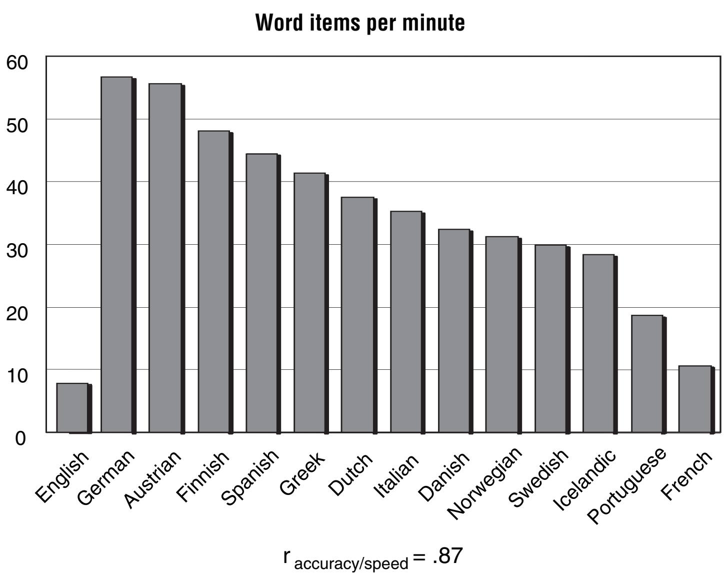


Fig 5.2b



Source: Seymour et al. 2003; illustration by Johannes Ziegler, Université de Province, France.

grade 1 and read fluently by the end of grade 2.[15] The Arabic script is simple when vowels are used, but without it, the readers must hold alternative words in their minds and decide very fast which ones make sense. (This is particularly challenging in Farsi, Urdu, and Pashto where vowels are not predictable.) The irregularities of English present special problems and children must learn lists of frequent words in early grades. Accuracy among 7-year-old German children in grade 1 was 92 percent compared to 69 percent for English-speaking children.[16] Overall, *English-medium students require 2.5 or more years of literacy learning to master the recognition of familiar words and simple decoding that is learned in one year for languages with simpler spelling rules.*[17]

Reading Benchmarks and Norms

Textbooks and curricula worldwide (usually formed for middle-class standards) expect reading fluency to be achieved early, as in OECD countries. Benchmarks of reading competency exist in some countries, and they approximate the speed needed for the working memory to retain a sentence. In the United States, suggested reading norms are 30–70 words per minute for grade 1 (oral), 60–100 words per minute for grade 2 (silent), 90–120 words per minute for grade 3, 110–140 words for grade 4, 140–170 for grade 5, and 160–190 words per minute for grade 6.[18] Similar benchmarks exist in Chile, where the teacher-to-teacher network program of the Ministry of Education set goals for grades 1 and 2 at 30 and 70 words per minute, respectively.[19] The Chilean nongovernmental organization (NGO) Educando Juntos has proposed goals of around 34 and 64 words per minute for grades 1 and 2, respectively.[20] A Cuban expert suggests 30 words per minute at the end of grade 1 as a reading speed for a "normal" child.[21] A study from Spain reported averages for the grade 1 and grade 2 of about 50–55 and about 75 words per minute, respectively.[22] Among the low-income Spanish-speakers in the United States, a speed of just 30–60 words per minute in Spanish in grades 1 and 2 is used as an index of disadvantage.[23] These at-risk students were typically reading at about 35 words per minutes in grade 1, and around 60 in grade 2. A European cross-national study defined fluency operationally as the reading speed of 2.25 seconds per word (27 words per minute), which children attain before the end of grade 1.[24]

Reading involves a paradox. *Slower readers read less material but use up more working memory*. They must make more effort to read, muster more attention, and may still lose part of the message. Children who read haltingly are probably functionally illiterate. They may puzzle out some phrases, but they cannot read or understand the volumes of text needed to learn the curricula. The relationship between reading speed and comprehension has been verified by educational researchers, but the linkage of this phenomenon to memory mechanisms has not been widely understood.[25]

Certainly, speed and accuracy are not sufficient for comprehension. As with liturgical languages, children may read fluently and understand nothing. Vocabulary knowledge, inferences, comprehension of text structure, and self-monitoring are important for spoken and written communication, and explicit instruction is needed in these skills. But working memory seems to be the only gateway to comprehension. As the biology of reading is understood at this time, it is essentially impossible to read haltingly and comprehend much material.

Reading Issues Affecting the Poor

In English and other languages that have complex spelling and unclear vowels,[26] children must look at larger chunks of writing and find words with a likely pronunciation. Extensive language knowledge and phonological awareness are important advantages, and the poor are slower to acquire reading skills. For example, British low-income children show delays in letter identification and learn to read about a year later than middle-class children.[27] In languages with simpler spelling like Spanish, beginning Hispanic readers tend to focus on syllables and do not have to depend on knowing the words in order to decode them.[28] Overall, however, the more limited phonological awareness and language use of the poor create early disadvantages that do not disappear in subsequent grades without intervention. Complex language knowledge is needed to get past decoding and understand the message, as well as to understand expressions used in school.[29] Thus an important early school activity is to build vocabulary and phonological awareness. A few hours of language games in grades 1–2, such as clapping to count syllables, learning rhymes, or deleting initial letters are invaluable aids in reducing inequity (also see Chapter 2).

Does poverty or malnutrition prevent children from learning to read? No reading research has been specifically carried out on malnourished populations,[30] but evidence suggests that if the neural circuits used in reading are functional, children can learn to decode and read fluently. These circuits are typically functional by age 4–5, so even with some delays they ought to be operational by school age. Thus, the developing brain has the means to learn automatic "mechanical" reading early on. Even moderately retarded students can learn fluent reading.[31] However, malnourished children may have more limited working memory capacity and shorter attention spans (Chapter 4), may have limited vocabulary and may not comprehend well. They may need more hours of instruction and practice. It may be worthwhile to focus on fluency first and build vocabulary afterward so that the children can retain a sentence in working memory. As working memory capacity increases with age (Chapter 4), higher grades may understand printed material more easily than earlier grades.

The evidence thus suggests that with sufficient instruction even poor students should decode material in their textbooks and attain fluency by the end of grade 1, or at the latest by the end of grade 2. What then are the reasons for the widespread delays? Different countries may have different problems, including the following:

- limited hours of instruction, inattentiveness by the teacher, lack of training
- insufficient practice due to a lack of textbooks (Chapter 11)
- lack of reading practice at home, which middle-class parents offer their children
- spelling complexity, especially when a local dialect deviates from the official language (for example, Creole English or Moroccan Arabic)
- limited knowledge of an official language, particularly one that is spelled irregularly as in Francophone and Anglophone Africa (Chapter 6)
- ambitious teaching methods, such as whole word instruction and early writing composition ("text production") with critiques and analyses as early as grade 1 (prevalent in Latin America)
- vision problems and unmet need for eyeglasses
- dyslexia, though relatively rare outside the English-speaking world

Dyslexia consists of abnormal activation patterns in the occipito-temporal pathway but possibly in other areas as well. People with dyslexia read haltingly, have poor short-term memory for verbal sounds, poor speech perception, and have difficulty becoming automatic readers. Disruption in their neural systems is evident at a preschool age. The problem is often hereditary. Many brain imaging studies have found atypical neural connections during reading between language centers and phonological processing tasks.[32] One reason is a generalized inability to filter out noise from signal.[33] About 5 to 15 percent of U.S. children are affected with dyslexia, and the English spelling may cause problems to susceptible people. Dyslexia symptoms reportedly appear half as often among Italians who learn simple spelling rules than among British children, even when Italians have dyslexic brain patterns.[34] Some aspects of dyslexia can be overcome with time, materials, and special techniques, though reading speed often remains a problem. These resources are generally unavailable to the poor in low-income countries.[35]

Teacher diligence or indifference towards poor children may determine reading achievement. In one study, Peruvian first and second graders at the bottom half of the income distribution were asked to read a brief passage aloud and to answer simple comprehension questions. Only 25 percent of the first graders and 41 percent of the second graders were able to read one or more words in the text at the end of the school year. Predictably, children reading faster could answer more comprehension questions. However, not all the poor classrooms performed badly. In some schools, teachers had worked with the children more intensely, and the students read well.[36] One issue is that the less competent or less interested teachers often teach the lower grades and poorer children (Chapter 14).

An additional issue plaguing low-income children in poor and crowded schools is *lack of feedback for error correction*, an essential learning tool at the neuron level of the brain (Chapter 3). Children need someone to hear them read and correct them.[37] If parents cannot do this, someone else must, be it teachers, aides, or older children. For example, teachers in a Bangladeshi NGO must hear every child read for one minute a day and provide feedback.

Reading performance does not have to remain low. Rigorous interventions have been found to increase speed and comprehension significantly in a matter of weeks.[38] For example, the Indian NGO Pratham uses a common local phonics method to increase poor students' performance in 45 school days, in sessions of two hours per day, one hour for reading and one for arithmetic.

An intriguing implication from the reading automaticity research is that children who have become largely fluent readers before they drop out may read and understand text later on and improve their skills. (Research with Egyptian children suggests that this is indeed likely.[39]) *In countries with high dropout rates, the challenge thus is to make students automatic readers before they drop out***.** At any rate, acquisition of basic literacy and the ability to comprehend text is likely to be very rewarding to students, and those who achieve it may be less likely to drop out (barring critical survival problems). Thus, early acquisition of fluent reading may itself be a deterrent of dropout. Given the ease with which young children forget material, however (Annex I), more research is needed to define the age of sustained reading automaticity among the poor.

Phonics Versus "Whole Word" Methods

Normal as well as dyslexic students learn to read faster through methods that break down words into small segments (phonics).[40] This is the case even for Chinese children[41] and makes sense given the tendency of the nervous system to start with smaller units and chunk them into larger ones. Composing words from letters or syllables is particularly helpful for languages with simple spelling, such as Spanish, where letter combinations consistently represent the same phonemes.

In the early 1980s and before the biological aspects of automaticity were understood, some educators in the United States hypothesized that children learn to read naturally, as they learn language.[42] This idea engendered a grass-roots movement among teachers in the 1990s, many of whom were tired of drilling. The "whole word" approach came about partly because of spelling irregularities in English and the difficulties of teaching many of the words by breaking them down into sounds (phonics). In this approach, students do not learn sound-letter correspondences. Instead, they are expected to perceive words as patterns while teachers read aloud and figure out the ones they do not know from the context. They must pay attention to meaning, discuss ethical concepts of the books that they choose, read in pairs, write their own concepts in long sessions of sometimes primitive writing, and create art about what they read. (The entire method is often known as the "whole language" approach.) The sound-letter correspondences are given as instructions specific to the text rather than general rules.[43] Concepts are to be discovered rather than presented, because discovery promotes higher-order thinking. (See constructivism in Chapter 8). For example, students may be asked to search a text for all the words with the /o/ sound and then group them according to their spellings. Many areas in North and South America as well as in New Zealand adopted this method in the early 1990s.[44]

The whole word (and language) approach seems to improve students' attitudes towards reading,[45] but the discovery road to reading requires much time, individualized instruction, and teacher expertise. It tends to favor those who are better prepared.[46] It may be effective for middle-class English-speaking children, whose parents can support their efforts, but even for the irregularly spelled English language, phonics has proved to be more efficient. A meta-analysis in 1989 found no evidence that whole language programs produce stronger effects than phonics and may potentially produce lower effects.[47] Many other studies followed with similar findings in light of the increasing concerns over functional illiteracy in the English-speaking world.[48] In New Zealand, where 20–25 percent of all six-year-old children have received expensive and intensive remedial reading since 1991, it was found that more intensive instruction with the same method led to little improvement.[49] A seven-year British study concluded that children taught to read through *synthetic phonics* were 3.5 years ahead of expected performance for their age in reading words, 1.75 years ahead in spelling, and 3.5 months ahead in comprehension. There was evidence also that phonics helped closed the reading gap between children from poor and better-off backgrounds as well as between boys and girls.[50] In 2000, the U.S. National Reading Panel, constituted to resolve the long-standing reading issues problems in the United States, solidly endorsed phonics for the teaching of English.[51] Since then the whole language method has gradually fallen in disuse in the English-speaking countries.

Though appealing and inherently sensible, the whole language approach puts low-income children at risk for failure. Poor children may well be able to recognize complex visual patterns of script (see Box 13.1 on computer self-instruction), but limitations in vocabulary, phonological awareness, and working memory may prevent them from creating the necessary analogies between language and reading. "Constructivist" textbooks progress directly into stories without the introductory large-print letters and syllables that readers commonly have. Furthermore, some schools choose to teach without textbooks, and then the students may not have enough reading materials from the environment. Poorly educated teachers may lack the sophistication needed to create the context interpretation and analogies for children, particularly when classes are large and individualized attention difficult. Spending much class time on guesswork, artwork, and early text production may be lead to multiple difficulties for poor students.

Nevertheless, the whole language approach is very popular in Latin America (often referred to as "constructivismo"). As a result, students in middle-income countries such as Venezuela and Panama spend years trying to acquire skills that children in Spain learn in about six months. Third graders in Brazil may spend entire class hours writing one-line answers to simple questions, while still reading haltingly.[52] The result is low performance and higher expenditures for school systems that must accommodate repeaters. For example, the 2004 overall grade 1 repetition rate in Uruguay was 16.9 percent, and in low-income areas it was 25 percent.[53] In this middle-income country with a simple phonetic script, 35 percent of second graders could read only syllables.[54] Less efficient reading methods cost governments and other stakeholders time and money.

Some educators consider phonics-based methods mechanistic exercises that stifle creativity and inquiry. However, fluent reading is likely to enhance these desirable qualities in students. Since research has shown that with intensive practice skills improve in only a few weeks, the more mechanistic stage of education should last at best a few months. Getting the mechanics right is thus not necessarily a distraction from creativity, and accomplishment may actually reinforce students. Ideally, literacy programs should combine phonics instruction with student selection of texts and authentic learning tasks as children learn the basics.

How should textbooks be designed to facilitate reading acquisition? Danish research, which may be applicable to other languages with rather complex spelling rules, suggests emphasis on regularity and practice. More effective textbooks were found to use more regular words so that the children learned the main rules of the correspondences between letters and sounds before the exceptions were introduced. These books also had more text and used the same words many times. They used high-frequency words thought to be part of the children's vocabulary. And the words were relatively short so that most of the children could sound them out without putting too much stress on their short-term memory.[55]

Policy Implications

Donor and government agency staff are frequently unfamiliar with reading issues and may not realize the extent of the problems or potential solutions. Although reading methods are usually considered a local initiative, there is sufficient and consistent research to favor specific recommendations on achievement levels and methods. It is reasonable to set a country-level goal that *by the end of grade 2, almost all students should read fluently—that is, at about 45–60 words per minute.*

Box 5.1. Sixty Words per Minute for All

The ingredients necessary to produce fluent reading include the following:

- Teach sound-letter correspondences, starting with the smallest units possible in a language.
- Use language games to raise awareness of individual sounds and the start and end of words.
- Teach reading in a known language to take advantage of the word superiority effect.
- Give lots of practice and feedback, and ask each child to read aloud for one minute every day.
- Provide textbooks, particularly for home study.
- Devote most of the class hours in grades 1–2 to reading and math and use time well.
- Teach vocabulary so that children can comprehend as speed increases.

By the end of grade 1, children should "crack the code" and read haltingly. By the end of grade 2, children should read frequent words with the speed of about a word per second, though they may stumble upon unknown words. Their intonation should be appropriate to meaning of the text, indicating that they are maintaining sentences in their working memory and are making the adjustments required by the meaning. Interesting stories in simple language are likely to help struggling students persevere.

Source: Author.

The science that links reading to comprehension leads to a *quantitative model of reading efficiency that has a simple and transparent monitoring indicator*. This in turn makes it possible to establish goals and benchmarks for the early grades. In each country and for each language, parsimonious ways must be found to teach reading. Teacher training and supervision should be directed toward achieving this goal. Communities may be easily trained to recognize the signs of fluent reading and hold teachers accountable to this standard.

To increase the hours and opportunity of practice, textbooks should be available for students to take home, not just for reading at school (see Chapter 11). Small sums (available through school improvement grants) may be used to entice older students to spend time guiding younger children to read if their parents cannot do so.

Spelling complexity implies that *it may cost more to learn reading in some languages than in others.* Children studying in English, French, and (to a lesser extent) Portuguese need more time and better language command in order to decode compared to children studying in phonetic scripts such as Bahasa Malaysia, Spanish, or Armenian. The added time and support needed to make nearly all children literate imply higher salary- and non-salary recurrent expenditures in Francophone and Anglophone Africa as well as in the Caribbean. Schooling the poor in Urdu and Pashto might also require more time given the need to guess vowels early on and essentially memorize entire words as if they were Chinese ideograms. Similarly, the syllabic Indian scripts have hundreds of combination symbols (for example, 510 total in Kannada and about 300 in Tamil), and new ones may be encountered through advanced primary grades. Some are visually confusing, and stu-

Box 5.2. With Efficient Instruction, Children Can Learn Multiple Scripts Simultaneously

Children in the Maldives learn three scripts in grade 1: Dhivehi, the national script, which has a simple phonetic spelling; the Latin script for English; and a voweled Arabic script for Koranic reading. All students have textbooks and the initial language of instruction is Dhivehi. During IEG visits to classes, students were engaged in learning and time was used well. Informal reading tests and teacher interviews in a sample of schools in this middle-income country suggested that practically all second graders could read these scripts fluently.

Source: OED 2002b.

dents may have error rates of 60 percent in grade 2,[56] compared to virtually zero among students of simply spelled European languages.

Reading complexity is reflected in the curricula of some countries (as in East Asia; see Chapter 10), but not necessarily in countries that have traditionally schooled a small middle class. The donor community has not taken spelling complexity into account when determining program cost. Underfinancing may be to some extent responsible for the modest learning outcomes. Incremental unit costs might be calculated as a function of students' reading speed and accuracy at least in the first three years of schooling, when large numbers fail.

Research Needs

Most research cited in this section was conducted to understand dyslexia, particularly for English speakers, and does not answer questions pertinent to the achievement of poor children. Research must be carried out with low-income populations in multiple countries to define the amount of time needed to attain fluency under various conditions (including malnutrition), particularly given instructional time limitations (Chapter 10). It is also important to estimate the incidence of reading disabilities among the poor and the age at which fluency becomes permanent, even if a child drops out. The effect of essential fatty acids (Chapter 2) might be tested in randomized trials as a means of speeding up reading acquisition.

Some of the neurologically oriented research may have been difficult to carry out in developing countries around 2006; however, functional magnetic resonance imaging (fMRI) equipment exists in countries like India, Brazil, and South Africa and could be put to this use. Portable technologies and infrared transmission may ultimately make such equipment usable inside or near classrooms. Diffusion-tensor imaging that tracks white matter in the brain can make important contributions to the education of the poor.

6
Why Mother-Tongue Instruction Improves Achievement

Learning Essentials

For many children, education in another language is more difficult than expected. The deficits in native language development common among the poor (Chapter 2) may inhibit the rapid acquisition of a second language. Mother tongue instruction is a prerequisite if Education for All is to be achieved, particularly when the official language has complex spelling rules. The official language should be taught to children as early as possible. However, it should become the platform for learning new information only after children know it sufficiently well to process complex sentences and vocabulary. A gradually decreasing percentage of mother-tongue instruction seems to be an effective way to introduce an official language.

Visitors to French-medium primary schools in sub-Saharan Africa are surprised to find out that children may understand little of what they are told and merely repeat verbatim what they hear. Sixth graders in rural areas may read haltingly or in monotone and be unable to answer comprehension questions on simple passages. Why are schooling outcomes so poor?

Many countries have multiple languages and a need to teach in a common language. In countries like Romania or Indonesia, children speaking minority languages must learn the official language of instruction. In many others—including most countries in Africa and the South Pacific—the lingua franca is foreign to everyone (for example, English, French, or Portuguese). The countries with multiple languages have various language-instruction policies. In some countries, students may study in their mother tongues in lower primary grades and then switch to the lingua franca. In others, logistical and political complexities result in the use of the lingua franca for all grades. The latter approach is preferred in much of Africa and impacts some of the world's poorest countries.

There are definite advantages to learning a second language at an early age.[1] The earlier grammar is learned, the easier and faster it is mastered. The time to learn a language most efficiently is from age 3 to about age 8;[2] then the ability falls off dramatically and steadily until adolescence and then again until adulthood.[3] After age 8, children are no longer in their prime language-learning years, but as their working memory and reasoning ability increases, they can put explicit grammar rules to use. Non-native students in primary and secondary years become fluent in about a year and eventually competently master a language.[4] With help, they may be able to catch up with students studying in their native language, although the latter double their vocabulary every two years between grades 1 and 5,[5] and by grade 5 know 40,000 words. However, the literacy rate among speakers of minority languages worldwide is low, reported at 20–30 percent.[6] If children are poor and also study in an official language they do not know well, how serious are the problems that arise?

Proficiency in a first language predicts success in studying a second.[7] Better-off children can benefit from bilingualism because a second language added to a rich knowledge of a first language results in complex knowledge networks *(additive bilingualism).* But poor children often have a limited vocabulary in their first language, so a second language may replace elements of the first (*subtractive bilingualism)*.[8] The reason is not well understood; the result seems to be a limited knowledge of both languages and a vocabulary too limited to make sense of classroom material. It then becomes difficult to build knowledge networks on various topics and attach new information.[9] For example, a child who knows the meaning of "justice" or "honesty" in one language can acquire the terms in another but faces a harder task if she has to acquire both the label and the concept in her second language. In particular, poorly fed students who often have a more limited working memory may need more time to acquire vocabulary (Chapter 4).[10]

Beginning learners and readers must quickly reach a threshold of language knowledge where they start to learn subject matter from context. Research on students with English as a second language shows that in English, with just 1,000 words, one covers 72 percent of the text. But to successfully guess the meaning of unknown words, at least 95 percent coverage is needed. If books are written relatively simply (such as novels for teenagers), 3,000 words provide a 95 percent coverage in English. Thus a benchmark of roughly 2,000–3,000 words is needed for children to understand the content of lessons sufficiently.[11] To get to this level and keep increasing vocabulary as native speakers do, children should learn 1,000–2,500 words a year. But hearing a language is not sufficient to learn it.[12] The speech must be directed at students, and in large classes the opportunity may be minimal.

Figure 6.1. Grade 4 Students in Guinea Still Learning the Names of Clothes in French

Source: Author.

When students know only limited grammar and vocabulary, it is not even possible to create a basis to which to peg complex concepts, and the classes may get stuck in a simple level of discourse. For example, grade 4 students in Guinea still learn the names of clothes in French, while grade 5 students are asked to name what is in a picture (water, birds, pebbles).[13] Their vocabulary does not approach the 40,000 words that the typical native speaker of French knows by grade 5. Unfortunately, such problems may not be obvious to a casual observer. Children's ability to repeat sequences verbatim can fool adults, making them believe that children actually know what they say.

Instructional languages with orthographic complexities spell trouble. Even if children do not know a language well, they could learn fluent reading when the spelling is simple (as with Spanish, Romanian, Bahasa Malaysia, Armenian, or even Hindi). But official languages have often been written for centuries, resulting in irregular spelling. Children learning to read through English must memorize words spelled unpredictably, but they may not yet know their pronunciation, meaning, or related context (Chapter 5). In French they must learn how to deal with dashes, accents, and endings as they were pronounced about 600 years ago. As a result of these issues, most of the school time in sub-Saharan Africa is taken up with language and spelling instruction, such as putting the right accents on French.[14] Ironically, the neglected African languages tend to be phonetically written and very suitable for reading instruction.[15]

Phonological awareness and decoding skills transfer from one language and script to another. However, visual features such as letter shapes do not transfer.[16] For example, students who learn to read fluent Arabic in Koranic schools may be able to link sounds with letters but still need a commensurate amount of reading practice in Latin script. However, if they read an African language in the Latin script, transfer to English or French will be relatively simple, despite spelling complexities and differences in some letter values (for example, from Malagasy to French). Countries that have a choice (such as writing a language using Arabic or Latin characters) might choose the script of widest use and apply it to multiple languages.[17]

Children in foreign-language instruction need more time but get much less. In principle, language problems can be overcome through increased hours of effective instruction, private tuition, and a wealth of audiovisual materials. Instead, textbooks are scarce, teachers are poorly trained (and may not know the lingua franca well), absenteeism is high, and class time is used poorly. The poor cannot afford private tuition and the national curricula may have insufficient space for both a new language and basic skills. To make things worse, hours in the crowded schools of some countries (like Niger, Mali, and Burkina Faso) have been reduced by about 40 percent to enable more students to attend (a policy known in French as "à double flux" or "double vacation"). Ironically this policy serves to screen students and identify the 2–5 percent who are gifted enough to learn with limited exposure.

All these issues create a bar that is too high for all but the most privileged to overcome. With school days lasting at best 2.5–4 hours a day, sufficient knowledge takes years to acquire. Unless students are very bright or well to do, their test scores are very low and many simply drop out or graduate from grade 6 functionally illiterate (as is the case in Niger and Guinea).[18]

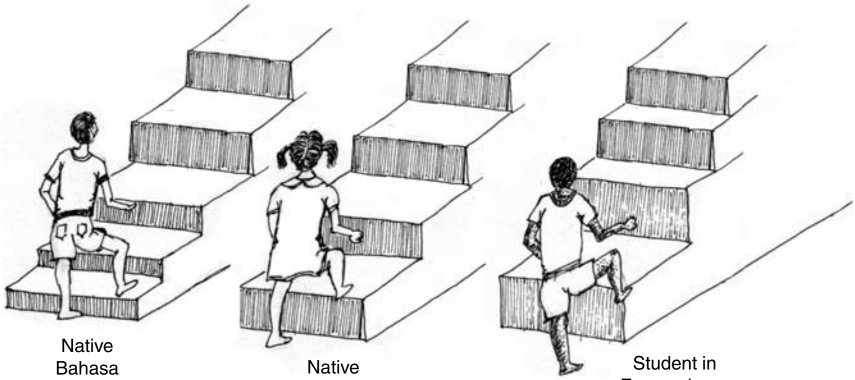
The Benefits of Bilingual Education

Teaching basic skills to poor children through language immersion may be detrimental, but bilingual education is a much more effective option. U.S. students receiving instruction in a native language and English at different times of the day were found to make the most dramatic gains in reading performance compared to their English-only peers.[19] This research is pertinent to multilingual low-income countries.[20]

Students require at least 5–7 years to approach grade-level norms on school tests that measure cognitive-academic language development in English (Figure 6.3). Students who arrived in the United States between ages 8 and 11, and who had received at least 2–5 years of schooling in their native language and home country, were the best achievers and took only 5–7 years to catch up in English. Those who arrived before age 8 required 7–10 years or more to catch up. The children arriving during early childhood (before age 8) had the same background characteristics as the 8- to 11-year-old arrivals. The only difference between the two groups was that the younger children had received little or no formal schooling in their primary language; this factor appeared to be a significant predictor in these first studies. (In countries where there are almost no native speakers in the schools, these reference points may be lost.)

The number of years of instruction in the first language is the most important predictor of reading performance in a second language. It is not important what the first language is, but rather how much cognitive and academic

Figure 6.2. Poor Children Studying in Official Languages with Complex Spelling Face Obstacles



Source: Author.

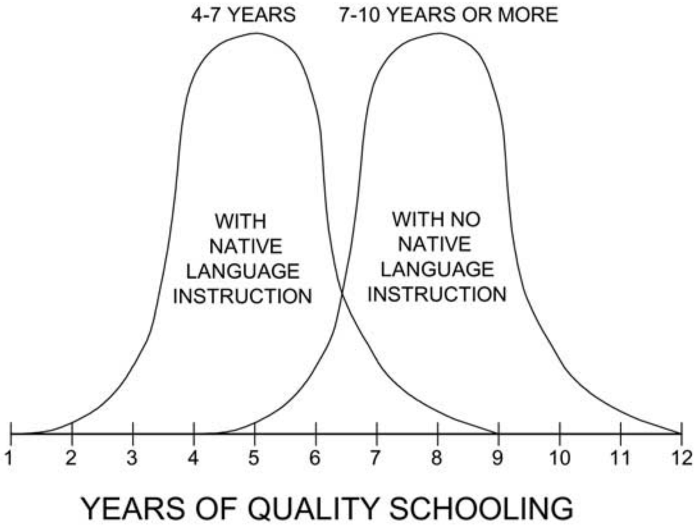
development the student has experienced in it. *The higher the students' achievement in the primary language, the faster they will progress in the second language.*

Deficiencies in the second language may not be apparent in lower grades, but they increase after grade 4–5, when the concepts become more challenging. For this reason, students in the United States who are taken out of bilingual education no longer catch up with English-speaking students. Merely immersing students in a second language or giving them separate intensive language instruction results in low reading scores many years later. Poor students who receive only immersion instruction are also more likely to drop out. Socioeconomic status becomes more important when the program is of low quality, and the poorer students do less well.

To catch up with native English speakers, minority language students must receive effective bilingual instruction (that is, studying parts of subjects in both languages). Otherwise they continue to score lower on basic skills tests throughout their 12 years of school. The performance difference between students receiving bilingual education and those receiving only English or English-as-a-second language instruction may be dramatic.

Research suggests that a very effective model of language introduction is 10 percent of foreign language in grade 1, gradually increasing to 20 percent, 30 percent, 40 percent, and 50 percent by grade 5. Students who start

Figure 6.3. Non-Native Language Speakers Need Several Years to Catch up with Native Speakers



Source: Thomas and Collier 1997.

school performing at grade level and receive such gradual bilingual education will catch up with English-language students by grade 5.

Accordingly, the *pédagogie convergente* of Mali gradually introduces French and reduces the local languages, but also introduces more "student-centered" strategies. Despite a lack of political support, textbooks, and training, students have a much lower repetition rate (3.7 percent versus 18.1 percent of French-speaking classes) and dropout (1.6 percent versus 5.7 percent of French-speaking classes). At the end of the first year, about 69 percent were promoted compared to about 52 percent of French-language schools. Classroom observations showed high rates of student engagement and writing skills in French, in contrast to French-only schools. Although the pédagogie convergente students are mainly rural and periurban, they scored slightly above French-only students in grade 6 standardized achievement tests conducted in French. Pédagogie convergente nominally costs 80 percent more to teach because of materials and teacher training, but it costs 27 percent less when repetition rates are considered.[21] However, political support for this program has been limited.

The positive results of literacy in mother tongues are evident in a program piloted in 800 schools in Zambia. The children learned to read just in local languages in grade 1 while learning English orally at the same time. Efforts

Box 6.1. How Many Years Are Needed to Teach Sufficient Language in the Schools of the Poor?

Children must learn 2,000–3,000 words through interactive speech before they can understand the content of the lessons sufficiently. To keep up with the increased complexity of school, they should learn about 1,000–2,500 words per year.

In second-language acquisition, a college student taking immersion class in a foreign language for three hours a week would require about four years or about 600 hours of interactive instruction and reading to attain relative mastery in one of the common languages. Given the limited instructional time and competence of many teachers, it is unknown how long it takes to provide sufficient levels of instruction.

Sources: Nation and Waring 1997, Putnam 1975.

were made to use instructional time well and employ interactive, "student-centered" methods. English writing was introduced in grade 2. The results were astounding. In 1999, students read on average two grade levels below their grade level in English and three grades below their grade level in Zambian languages; but in 2002, students reading and writing scores were 575 percent above baseline for grade 2, 417 percent for grade 3, 300 percent for grade 4, and 165 percent for grade five. Scores in Zambian languages ranged from 780 percent above baseline for grade 1 to 218 percent in grade 5. Subsequently, the program was introduced to all schools of the country.[22]

Political ambivalence toward native languages. Governments seem unable to reconcile political issues with instructional outcomes, particularly since the children of the officials themselves usually have little difficulty with the foreign language in school. Parental preferences pose an unexpected obstacle in bilingual education. In the words of one Segenalese father during an IEG evaluation mission, "*The child already knows Wolof; what is the use of studying in Wolof?*" Parents with limited or no education may expect a higher status or better family income if their children are educated in the official language. Frequently, the strong objections to local-language instruction are due to concerns that the language may acquire political importance in areas which try to set tribal differences aside. Reactions against national languages in Africa have been widespread and have resulted in reversal of programs in Guinea and Madagascar. However, the success of programs in Zambia, Mali, and Burkina Faso are encouraging.

Policy Implications

Immersion languages with spelling complexities such as English and French should be avoided for the poor at all costs. Children should first learn to read fluently in their mother tongue (assuming its script is used extensively in the country, or also used for the official language).[23] Logistics to teach multiple languages may be indeed complex, but ultimately mother-tongue instruction in the early grades may prove cheaper. The cost-effectiveness of bilingual education needs to be calculated, taking into account the costs of grade repetition and social costs of illiteracy.

Teaching children the basics in a mother tongue includes the use of dialects, such as Maghreb Arabic and various Creole dialects. Phonetically based writing of dialects may greatly facilitate the acquisition of the mainstream language, particularly when its spelling is complex. Children also need to be taught the change patterns between the dialect and mainstream language and learn to use them consciously.

A communication strategy involving mass media is needed to explain to parents the rationale for mother-tongue instruction and underline its utility if children are to learn the official language sufficiently well to progress in their studies. To deal with the political concerns involved in mother-tongue instruction, governments may explain that local languages have a preparatory role and may be phased out of curricula after grades 3 or 4.

In the most remote schools it may be ultimately impossible to teach sufficient language and make a transition to higher grades possible to many students. If that is the case, then fluent reading and math skills in a native language as well as basic concepts may be all that most may acquire. However, that may be sufficient for correspondence and personal needs.

Research Needs

A better understanding is needed about what is gained and what is lost when poorer children acquire a language for classroom use, given the instructional limitations of low-income countries. At what points and under what conditions does subtractive bilingualism occur? What ages and how much maternal language knowledge create the most susceptibility? What is the number of hours poor children must be exposed interactively to English and French before they acquire the essential patterns of grammar and vocabulary? Is that number of hours realistic given the usual amounts of instructional time? Answers could result in improved sectoral strategies.

7
The Development and Teaching of Numeracy

> ***Learning Essentials***
>
> Children have an innate sense of mathematics, but it is typically limited to very small numbers. Poor children often have a more limited intuitive sense of numbers than middle-class children, a problem compounded by limited language knowledge. Considerable practice and instruction are needed to understand concepts, but learning should include memorization of routine procedures, such as the multiplication tables, to speed problem solving.

When visitors to schools ask students simple math questions, the answers are encouraging. Young children often know simple addition and subtraction of one or maybe two digits. Thus, numeracy is rarely considered as acute a problem as literacy. In higher grades, however, children often know less than the curriculum prescribes, particularly in terms of multiplication and division, fractions, and operations with long numbers. These tasks subsequently pose problems in secondary education. This chapter presents information to facilitate decisions on numeracy issues.

Math seems to be hard-wired in animal brains; human brains compute elaborate statistics unconsciously for events and linguistic frequencies[1] and show an innate understanding of geometric concepts and maps.[2] Children have an innate ability to pay attention to and keep track of numbers, such as in a line of items, sequence of drumbeats, jumps of an animal, or numerical values represented in arrays. Infants are able to do some math a few months after birth. They can track a number of objects (maybe up to three) and they can estimate an approximate number; if items are added or removed, the infants notice the change. With small numbers, they seem to understand the difference between "a lot" and "a few." As language develops, children age 4–6 years form a mental counting line that allows them to solve verbal mathematics problems. Practically all languages have a number system, so normal adults use it to operate on mathematics using verbal symbols.[3]

To accomplish different tasks in mathematics, the brain recruits multiple regions, which are activated when children are learning or performing arithmetical operations. As these regions mature, people become able to manipulate numbers by using one of three actions (called the "triple code" model): (a) They see a number as a visual digit (for example, "3"); (b) They hear or read the number as a word, that is, "three"); and (c) They represent it as a quantity (for example, "3 is bigger than 1").[4] Depending on the processes undertaken, the information moves back and forth among these regions and recruits one or more of them. Two seemingly similar calculations can recruit different regions, such as having to solve the problem 4+5. A study showed that children having to choose between two results that were both close to the correct result used the verbal region if they had to perform the exact calculation. They used the quantitative region if they were given one grossly false result and the other approximately correct.[5]

So, children bring some mathematics to school, but the innate calculations are limited to adding and subtracting small sets and the concepts of "more than" and "less than." After the first few numbers, the quantities are approximate. And maturation alone does not bring about mathematical knowledge. Children are not biologically designed to command large numbers, large sets, the base-10 systems, fractions, multicolumn addition and subtraction, carrying borrowing, multiplication tables, radicals and exponents. To do all this they need schooling.

As with reading, many low-income children do not enter first grade with the same intuitive sense of numbers that middle-class children have.[6] They can usually answer questions involving the difference between large and small quantities but cannot make finer distinctions that involve gradations and number counting.[7] Mathematical difficulties in children occur frequently. They might be traced to the quantity subsystem, or to a poor connection between a quantity representation and both verbal and visual symbols. This connection takes time to be established, because it involves symbolic transformations that come with experience, both educational and cultural. Children may find it hard to move quickly and flexibly from one representation system to another.[8] Poor children's delays in language may also affect math.

Clearly, mathematical symbols deserve understanding rather than rote memorization. However, automaticity of routine calculations is important because of working memory limitations. Without knowing the multiplication tables by heart, students have to spend time calculating intermediate products and run out of working memory. This is equivalent to reading letters one by one rather than recognizing words. The rapid rote use of low-level concepts may help students grasp higher-level concepts, such as negative numbers.

Children may unconsciously resort to innate computations when solving a concrete problem, such as picking the best buy at the supermarket or giving the correct change. But when there is no context and children are asked to multiply two numbers, the rules for manipulating symbolic representations of numbers make little sense. The challenge is to make students understand how symbolic concepts connect to the natural math they can already do. There seems to be no shortcut other than practicing until the abstract rules take on a more concrete reality. Programs developed for low-income children—for example, Rightstart[9]—teach mathematics without a reliance on language, instead accessing the quantity representation system by offering a spatial or concrete objects metaphor for numbers, such as the metaphor of a number line or the Asian abacus.

Children's problems in advanced grades are compounded by incorrect or limited teaching of teachers who know little more than the students. Standardized achievement tests given to students and teachers in southern African countries indicate that teachers' errors mirror students' errors and achievement level. Ignorance of basic math, particularly of decimals and fractions, is often embarrassing to teachers and is not remediated by inservice or preservice training. Math by radio has been a long-standing project of the United States Agency for International Development (USAID) to supplement the instruction of weak teachers, but implementation logistics have limited its use.

The Effects of Language Switching in Math

People tend to use in calculations the language in which they first learned math skills.[10] Madagascar, for example, outperforms many other Francophone countries in math, because of early math instruction in Malagasy.[11] The language is not necessarily children's native language or even the language that is most prevalent in their environment. Although bilingual people are capable of performing mental computations in either language, they have a strong preference for the language in which they first learned math skills. For example, Nigerian students in private and public schools performed better when math problems were worded in their native language than in English.[12] Thus, bilingual education may be useful in addressing low math performance.

Language preference in math has important policy implications. One reason is that the language of instruction is repeatedly switched in many countries. For example, students in Mauritania start math in their mother tongue, go on to Arabic, and, in secondary school, to French. Creating and recreating automaticity for these very basic intermediate operations slows down calculation time, makes the working memory overflow with smaller chunks of information, and may draw students' attention away from the math and to the words. This is one more problem that students face in countries where an official language of instruction is used, and it deserves more research.

Policy Implications

The knowledge needed for the twenty-first century has math at its base. Given the poor understanding and performance many low-income children show in math, this issue deserves attention in policy dialogue. Teacher training must be provided in low-level math, using concepts and games (like Rightstart) that the teachers themselves can learn to use.

To facilitate fast and accurate calculations, children's language code should not be switched mid-way through school. For example, if children are to learn calculations later on in French, perhaps they should start with calculations in French early on.

Research Needs

There is a need to understand better the most frequent conceptual problems besetting the classrooms of the poor and experiment with remedies through teacher training. The effectiveness of games like Rightstart might be assessed for strengthening numeracy in early childhood education and primary school, as well as for their possible adaptation into local contexts.

8
The Cognitive Effects of Classroom Events

> ***Learning Essentials***
>
> Some classroom activities are more effective in raising achievement test scores than others. Those involving interaction, such as lecturing (for brief periods), questions, discussions, feedback, and evaluation, enable students to contemplate what they learned and retain it better. Lengthy "seatwork," copying, and some discovery-oriented activities are often associated with lower test performance in primary school. The challenge is to maximize the time spent on activities that help students retain, integrate, and use information to make decisions.

Class activity represents the moment when the government and donor financing gets converted into knowledge. Information is a valuable commodity for governments to care for, much like buildings and vehicles. So, how can one class hour be put to the best and highest use?

Cognitive research suggests that presenting information under certain conditions or in certain ways will result in knowledge that is more durable and more likely to be retrieved when needed. This is because information is encoded in very specific relations to existing items and must be retrieved through the same paths. Classroom time should be spent on activities that help students structure information in ways that it can later be used for decisions. Therefore, activities should be structured to take advantage of the conditions under which information can best be retained (Table 8.1, Annex II-B). For example, children studying the classifications of animals could be guided to recite Latin names (and forget them after the exam) or be prodded to explain why squid do not have fish bones and recall the information in a restaurant.

Events in class may seem chaotic, but they can be reduced into a finite number of activities that can be encoded through observation instruments.[1] At the primary level, some educational research has linked the frequency

Table 8.1. Most and Least Effective Means to Learn New Information

Information will be most memorable or easily retrieved if:	*Information will be less easily retrieved or memorable if:*
It receives students' attention	It is presented while student attention wanders
Students contemplate it or practice it immediately	The class goes on to something else or students merely repeat it almost verbatim
Students already know a lot about it (attach it to existing network nodes)	Related topics were not introduced before or students were absent
It connects to multiple parts of a student's knowledge network	Topics are presented with few connections to what students already know
Students classify it in their minds on the basis of meaning	The teacher presents disjointed items rather than a coherent categorization scheme or if students memorize items in series
It connects to multiple senses (seeing, hearing, touching, doing)	Students just listen to it or read about it
It is in some ways distinct from other items	The teacher drones on the same way and just gives a list of items
It is recalled and practiced often	There are few summaries and recapitulations
It is presented in small chunks over a period of time	Learned by cramming before exams or in long sessions
It can be put to immediate use	It is merely "good to know," without an immediate use
It is recalled in conditions similar to those during learning (for example, in class)	Linkages have not been made to the outside world or to potential uses
It is linked to rewards, humor, or other somewhat strong emotions	It is linked to strong negative emotions or personally offensive events

Source: Author.

of certain activities with test scores. This research in conjunction with information-processing research (Table 8.1) can help guesstimate how much students may learn in class how and to use the information. This framework can facilitate decisions that cannot wait until more research is conducted.

Government and donor staff often visit schools, and they can learn much from a brief visit. By sitting at the back and quietly observing for a few minutes, they can get "snapshots" of the activities carried out at that time and observe what percentage of students is actually engaged in learning tasks (also see Chapter 10). Asking a supervisor or inspector who knows the curricula to observe may help empirically assess whether the class is meeting the curricular expectations for that time of the year. In secondary schools, the content may be too sophisticated to give much information during a "snapshot," but student engagement can still be registered.

Examples of activities and their likely contributions to learning are offered below.

"Chalk and Talk" Lecturing (Very Effective for Brief Periods)

Though much maligned "frontal" or "direct" presentation of information by the teacher is an economical way to transmit information. A good teacher has a sense of what the audience knows and what concepts stand out in students' minds. She or he links new information to already existing categories and classifies new items in an orderly manner into pertinent categories. Thus listeners find in their minds multiple hooks on which to "hang" the information. Judicious use of the blackboard reinforces words with visual coding. The meaning of the material can be transmitted through examples, comparisons, implications, or imagery. Stories with the information capture the attention of students who wait to find out what happened at the end and result in much learning. Metaphors, analogies, explanations that fit students' networks are considered "clear"; students connect new nodes onto them and "understand." On the contrary, if a teacher jumps from one topic to another, students require more time to link items into distant nodes of their networks, and they may lose the contents of their working memory and fail to understand.

Lecturing is most effective if it accommodates children's attention spans.[2] When presentations last more than a few minutes, students' processing capacity may overflow. Passive listeners have few means of encoding material. They cannot use other modalities besides listening, reading, and writing. As their attention switches off and on, they may retain some items, but they may not be distinctively encoded. Particularly nondistinct and hard to retrieve may be the items taught in the middle of a class hour or a day (Annex II-B). Thus, densely seated students are often observed looking ahead but probably not retaining all that the teacher has said. In many

Source: Barnette and Benavot 2005.

cultures, questions or requests for repetition are discouraged, so material not attended to is effectively lost. Worse, monotonous lecturing is tiresome to both teachers and students, uses time poorly, and may lead to school avoidance by all parties concerned.[3] The best approach to maintain attention is to cycle activities between lecturing, discussion, practice, and evaluation. Frequent reading aloud and use of textbooks have been linked to higher achievement scores.[4]

Practice, Questions, Feedback, Discussion *(Very Effective)*

Teachers in high-scoring Cuba were found to engage more often in a dialogue with students, asking them how and why a given problem should be answered or to demonstrate reasoning for various solutions. Through such activities, students are likely to deduce rules from facts and later apply them to other situations. By contrast, teachers in lower-scoring Brazil tended to make fewer demands of students, often asking for repetition or assigning copying and having limited interactions with students. It is not as easy to deduce rules under these circumstances.[5]

Interactions between teachers and individual students help elaborate on topics, so they may facilitate subsequent recall. Voluntary student contributions are an indication that students are contemplating the material and perhaps finding uses for it. In many countries teachers often ask students to respond in a chorus. Addressing the whole class and inviting recall with little independent student contribution is related to lower scores.[6] However, in large class sizes that preclude questioning each student individually, choral responses may be necessary (Annex II-C). Memorization is useful for facts that belong together and for frequently needed procedures. Ideally the teacher should link the information to applications. Standardized answers may be more justifiable in younger grades, and extensive use in upper primary and secondary classes might be cause for concern.

Teacher working with one student. Often a student is asked to go to the blackboard to solve a problem or demonstrate that she or he has mastered a topic. The rest of the class is supposed to monitor the student or correct their own work. Short teacher interactions with one or two students may constitute elaboration. But blackboard exercises often take 5–10 minutes, particularly if students are slow and hide what they write with their bodies. Then the rest of the class may become distracted. Students in the back rows and far from the blackboard may be more likely to be off task. Lengthy blackboard exercises are frequent in the Middle East and Africa. Attention to one student without suitable tasks for the rest of the class risks wasting students' time.

Quizzes, announced and unannounced, provide needed feedback. Announced exams have the added benefit of review and reconsolidation during study and are linked to higher achievement.[7] But classroom tests require extra work by the teacher and may be given rarely in low-income schools.[8]

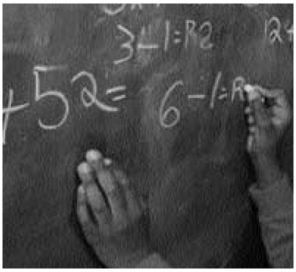
Individual Seatwork (Limited Effectiveness)

In principle, practice should improve student performance, and the more time students spend on something, the more they are likely to recall. There are some examples of effective seatwork; prepared problem sheets are used extensively in Cuba,[9] and higher-scoring students may perform well with independent seatwork activities.[10] The video studies of secondary-level math instruction in industrialized countries also suggest that seatwork may be beneficial if problems involve thinking and reasoning.[11] However, the practice-oriented activities described as seatwork in research studies of primary schools are generally associated with lower performance compared to "frontal" teaching and practice reading aloud. These include solving of routine problems in Brazil or sustained silent reading.[12] Findings were similar in Jamaica and the United States.[13] Brazilian research also found that student engagement dropped after the first 20 minutes of class, and teachers gave students more seatwork in the later periods of the day in order to rest.[14]

The reasons for the limited effectiveness of seatwork have not been investigated directly, but students pay may less attention during routine practice,[15] and those who do not read well may not do as much work as expected. Also research suggests that comprehension may be easier during listening than during reading.[16] Thus seatwork may be most effective if it involves invention rather than practice and if it lasts only 5–10 minutes rather than longer blocks of time, and if it is used to advance understanding in a lesson that is taught.[17]

Source: Barnette and Benavot 2005.

Extensive *copying* is a seatwork activity that has proved problematic for various reasons (see more in Annex II-D). It is important for the development of basic writing in early years, but the contribution of copying to learning in later years is unclear.



Source: timss.bc.edu/timss2003i/frameworks.html.

Copying usually takes place when there are insufficient materials and happens more often in lower-income schools. For example, it was found to be more frequent in lower-performing Jamaican schools than in better schools.[18] Copying may be an indication that students have fallen behind. For example, an IEG mission in 2003 observed Panamanian fourth-grade students copying problems that they could not in fact read and solve.

Group work is considered desirable overall, but it was found to be negatively associated with achievement in the Trends in International Mathematics and Science Study (TIMSS) mathematics tests.[19] Countries like Cuba and private schools that have a lot of control over their students rarely engage in it. Group work and cooperative learning may be viable solutions in very large classes (50–100 students) where the teacher cannot possibly attend to all (Chapter 4). However, noise levels rise in class and teachers may find it hard to control students or know who works and who does not. Group dynamics have been the subject of considerable research in OECD countries, but there has been little application in lower-income countries (Chapter 13).

Projects (Limited Effectiveness for Basic Skills)

Projects are activities that span several days or weeks and focus on a specific goal. They demand application and synthesis of knowledge and may help teach important cultural principles and values. But procedural activities (such as cutting up and pasting magazine articles, drawing, and looking for materials) may crowd out the time needed to learn the prerequisite skills. In Brazil, for example, an IEG mission in 2002 observed the handiwork of overage students in a remedial class, which included notebooks of magazine articles collected, cut up, and pasted. The hours that had been spent on art might be fun to students but could have been better spent on more reading. Less structured activities may be unsuitable for children who are falling behind. Perhaps for these reasons, projects are often related to lower student performance.[20]

Noninstructional Activities *(Ineffective)*

Some off-task time is necessary for transiting from one task to another or interacting with visitors in a class. However, noninstructional periods are frequently observed in low-income countries. Teachers may spend much time in “classroom management” such as collecting and handing

Box 8.1. Activities and Achievement in Low- and High-Performing Jamaican Schools

In a study of high- and low-performing Jamaican schools, the scores of students in top schools exceeded those of students in the bottom by 309 scale score points—estimated as the equivalent of 1.5 years of schooling. Both types of schools engaged in whole class instruction and assignments, but details differ. Bottom Jamaican schools were found to socialize students for unskilled occupations and emphasize discipline and hard work, whereas top schools emphasized academics and had a relatively higher degree of community involvement. The following variables significantly predicted achievement:

- time spent on written assignments (seatwork) in class (–47 points)
- increased testing, weekly in top schools, 1–3 times per month in bottom schools (+38 points)
- vision tests, a proxy for interest from community organizations (+25 points)
- instructional assistance and leadership by principal (+15 points)
- intensity of textbook use (homework, remediation, pointing to pages during class) (+14 points)
- time spent on whole-class instruction (–14 points)
- late arrival of textbooks (–13 points)
- curriculum or pedagogy major theme of staff meetings (+11 points)
- percentage of students with desks (a proxy for overcrowding) (+10 points)

In top schools, faltering students often got help. In bottom schools, the weak students were isolated in favor of those likely to pass entrance exams to secondary school.

Sources: Glewwe et al. 1995, Lockheed and Harris 2005.

out textbooks, looking for materials, grading papers, talking to colleagues, and disciplining students. Classes may also finish ahead of time, and students may be dismissed or may wait for the bell to ring. U.S. research has shown that time spent on organizing activities, social interactions, and discipline was related negatively with student achievement.[21]

It is not possible to keep all students occupied all of the time in class with curriculum-related activities and to control everything they do. Some less productive activities must happen some of the time. However, since the 1980s in the United States it has become clear that "active" or "interactive" teaching is related to better achievement.[22] This means that a teacher instructs students; that is, lectures, demonstrates, leads recitations and discussions, and frequently interacts with students during assignments. This contrasts with the teaching style in which students frequently work independently on academic subjects or engage in nonacademic work. In the United States, greater amounts of teacher-directed activity (for example, letter-sound instruction) were found to predict greater growth for low-ability children, while greater amounts of child-directed activity (for example, sustained silent reading) predicted better growth for high-ability children but not for low-ability children.[23] Structured, directed activities may thus be more beneficial for lower-income children than self-directed, discovery-oriented methods (Chapter 9).

The relationships between classroom activities and learning outcomes reflect to some extent teacher decisions and difference. Personal commitment and willingness to work with students result in higher achievement.[24] Preparedness for class, regular assessment of students' work, and use of instructional materials were found to differentiate between high- and low-performing schools in Uganda.[25] Some teachers may give their students 180 extra hours of teaching per year.[26] Feedback and training has been found to change the frequency with which teachers use activities and also improves instructional time. In a U.S. study, students gained on average six months more in reading than students in a control group that did not get feedback. Further observations indicated that teachers getting feedback maintained most of their behavior changes, whereas control group teachers became more lax and less task-oriented.[27] Clearly classroom activities must become more effective if poor students are to learn basic skills (Annex Table A-1).

Benchmarks for student engagement rates. Years of primary-level classroom observations suggest that interactive engagement in learning with a teacher or other students should take up at least 50 percent of the time; such work includes *lecturing, reading aloud, discussion, group work, and kinesthetic activities where appropriate*. Noninteractive, individual work should take up at most 35 percent of the time; such work includes *seatwork, copying, watching other students write on the board, and teacher monitoring)*. Finally, no more than 15 percent of the time should be spent on *organization activities, transitions from one task to another, and discipline.*[28]

How should classroom time be organized so that interactive time is maximized and connected knowledge is produced? One teacher maxim is *keep students occupied all of the time*. A widely used set for classroom activities comprises the following:

- Say something catchy to attract student attention.
- State the objective of today's lesson.

- Explain why the new material is important.
- Link the new material to previously taught material.
- Present new material and offer practice (switching between presentation and practice if needed).
- Evaluate students' acquisition of the new material.
- Summarize.

Policy Implications

Governments might train teachers to use classroom time for activities most likely to result in information that is retained and usable, particularly for poorer students. With the help of observation instruments, governments can obtain valuable behavior samples from various classes and use the information to improve training and supervision.

Research Needs

In principle, the incidence of various classroom activities could be used to predict outcomes in standardized achievement tests and improve the efficiency of school systems. However, the data are sparse. More extensive and detailed research is needed to link classroom activities with learning outcomes. Specific research is also needed to forge a closer linkage between activities and the ways the brain is set up to process information.

Though classroom observations have been valuable, real-time information from learners would contribute more specific information, particularly in conjunction with memory consolidation research (Chapter 4). Data could be collected on recall after class. As the cost and portability of technology improve, experience sampling methods and portable brain imaging techniques may become more feasible.

PART II

Resources for Effective Instruction

9
Which Instructional Methods Are Most Efficient?

Learning Essentials

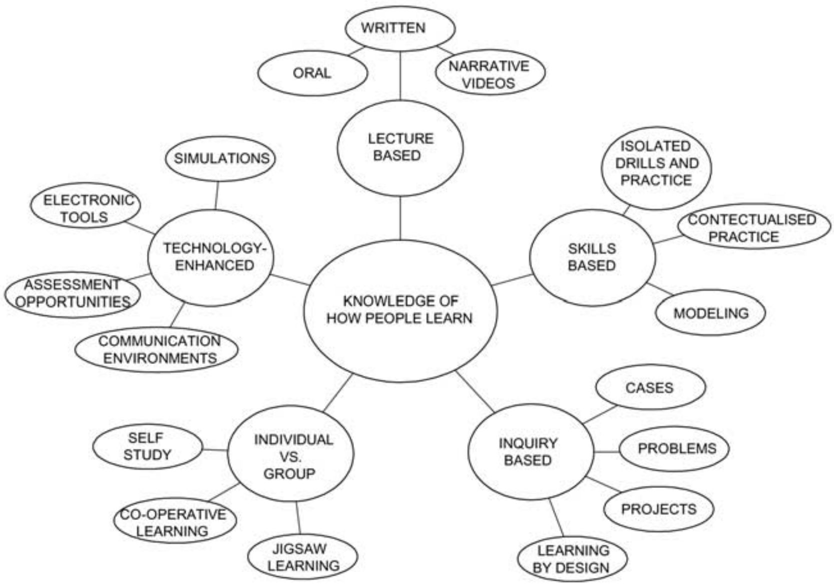
Teaching methods are often viewed as local initiatives and presumed to be equally valid. However, some methods may use time and resources more efficiently than others, particularly when teaching the poor. The choice of certain methods can have large financial consequences for governments. This is why student outcomes should drive selection rather than philosophy or educational theories.

Staff working in the education sector hear the names of various methods: active learning, child-centered learning, student-centered teaching, joyful learning, constructivism, outcome-based instruction, direct instruction, discovery-oriented, inquiry-based, technology-centered, project-based, group-oriented, individual-based, and many others (Figure 9.1). Many emphasize students' engagement, pleasure, or discovery over "traditional" methods.

Methods are usually pedagogical concepts invented by charismatic educators, such as Maria Montessori, Paulo Freire, or Jean Piaget. Actual application varies according to teacher preferences; therefore, many methods are hard to define. It is unclear, for example, what "child-centered" or "active" learning consist of.[1] Governments and donors may consider different methods to be local initiatives that are equally valid, and may leave decisions about them to consultants. Thus, large amounts of money for training and materials may be invested on the basis of dubious guidance and scant evidence.

Methods must be clearly defined and pilot-tested before large-scale application. This often does not happen. For example, the government of Honduras decided to apply constructivist methods with little prior testing and found unexpected problems that included lengthy delays in the distribution of materials. In Brazil, the sensible constructivist advice to focus

Figure 9.1. Different Dimensions and Methods of Teaching



Source: Adapted from National Research Council 2000, p. 18.

on activities that engage student attention was transmitted to some teachers as advice to use a variety of entertaining activities, with little concern about learning effectiveness. Adopting large-scale changes on the basis of untested hypotheses may result in considerable wastage and may potentially damage students.

Essentially, methods consist of a finite number of activities in various frequencies and sequences. The activities can be evaluated on the extent to which they use time well and deliver well-retained and useful information to students (Chapter 8; Table 8.1). Therefore, the primary concerns for determining whether teaching methods should be financed would be as follows:

- How efficiently does a method use class time in learning and practicing objectives?
- A good teaching method should help students automatize small units and chunk them into larger units (Chapter 3). Is material taught in sufficiently small steps to enable nearly all students to master it? Does the method also permit more advanced students to progress faster?
- Ultimately, how efficient is a certain method compared to alternatives, particularly when lower-income students are concerned? What

percentage of students masters the prescribed skills within a certain period? How much does mastery cost per student given the success rate, teacher training costs, and cost of materials?

When research is limited and instructions are unclear, results can be unexpected. The following section discusses two popular methods that have been applied with low-income students and their outcomes.

The Pros and Cons of Constructivism and Discovery Learning

In the 1930s Vygotsky promoted the premise that children actively construct their knowledge through social interaction rather than simply absorb ideas, and that teachers must help them reach the next "zone of proximal development." In the 1950s Piaget emphasized that learning occurs when a contradicting viewpoint challenges previous knowledge. Novel combinations of ideas are to be achieved though play and experimentation.[2] As knowledge about cognitive networks spread in the 1990s, these ideas fused into the constructivist philosophy. For many, this is state-of-the-art teaching.[3] Constructivism is associated with liberal politics and concern with children's welfare, whereas more structured instruction is sometimes associated with conservative views and behaviorism. In principle, the constructivist teacher provides the social milieu and the materials but does not lecture or guide. Children are expected to learn from materials used in the environment. This philosophy is often mentioned in conjunction with methods such as discovery learning, whole-word reading (under the assumption that children learn to read naturally), early writing (after observations of how young children conceive primitive writing symbols), a rejection of memorization, and sometimes a choice to discard textbooks. In other words,

> The role of the teacher changes from that of purveyor of information to one akin to a symphony conductor creating an atmosphere conducive to learning and encouraging the development of students' feelings and emotions. Using current learning theory, teachers will create events and introduce materials and ideas into the classroom that will encourage the development of neural network connections in their students. When this occurs, the classroom then becomes constructivist, one where students construct individual meaning from the information and activities presented. The use of music, video clips, odors, and even tastes can be used to connect new learning to already existing brain pathways. The introduction of discrepant events, new information presented in a way that seems to be dramatically inconsistent with prior

> knowledge, is another entrée to significant learning because the brain appears to scan its environment to identify and explain the unusual and/or dangerous. This provides the teacher with a hook, a place to hang important new concepts. Both student and teacher are viewed as knowledge workers in a brain-based learning environment. The young learner must actively manipulate information and material to grow new connections." [4]

While there are many enthusiastic articles about the constructivist philosophy, there is little hard evidence regarding its benefits for poorer students.[5] Learning outcomes in constructivist classrooms of South Africa have been low (Box 9.1), partly because reading instruction through the whole-word approach is inefficient. Classroom observations and test scores suggest that students may need more time than is available to them to derive principles in the constructivist way, and many may be unable to do it. Furthermore, the philosophy downplays teacher responsibility and may be appealing to some who might want to avoid accountability.

Box 9.1. Constructivist Curricula, Illiterate Artists? The Case of South Africa in the 1990s

An example of misunderstood constructivism comes from South Africa. Here teachers were renamed to facilitators. There were no lessons or subjects, and teachers were not supposed to help students construct their knowledge with appropriate materials (that is, they could not use existing materials). Students were supposed to create knowledge on their own and pass it on to others. Memorization was banned. Likewise, students were no longer supposed to learn reading and writing. Instead they had to negotiate meaning and understanding. So, a lot of people understood this as not requiring reading and writing. Furthermore all subjects were supposed to be integrated in curricular terms, so there was no specific time for reading and writing. Given that students had to teach each other and teachers should only facilitate, teacher absenteeism went very high. The teachers just popped in to check whether students were learning.

For example, if was the topic was food, the teacher asked what children had for breakfast, and the children then discussed in groups what foods they liked and disliked, and cut out pictures of foods from magazines (hands-on experience). This went on up to grade 7. Not unexpectedly, the learning outcomes were very low.

Sources: Nykiel-Herbert 2004a, 2004b.

Finally, cognitive networks do not work as conceived in the 1980s. Connections among nodes are convoluted. Some links are stronger than others, and inhibitory mechanisms prevent entry to certain parts of a network. Because information is encoded very specifically, a new item will not "stick" without the right prior knowledge (Annex II-B). It is impossible to make connections easily from every part of the network to every other. Therefore, it is practically impossible for most children to derive principles from mere presentation of data; for example, they do not automatically see a string of beans as elements in a set or points on a line as numbers.[6] And when children can realistically discover principles, the process may take considerable class time, much more than is realistically available to many of them.

Discovery learning. The donor community has shown interest in financing inquiry-based methods for lower-income countries. Discovering knowledge rather than merely learning it may enable students to remember it better (Annex II-B, generative learning). However, the process often requires materials that may not be available, so inquiry-based teaching has been difficult to implement on a national scale.[7] Furthermore, the efficiency of the method has been challenged: An experiment showed that children taught a control selection of issues could learn the material in 30 minutes and retained it seven months later, whereas those who had to discover the principles took longer and made errors. "Teacher-centered" methods (in which teachers actively teach, as opposed to observe or facilitate) seem particularly effective for procedures that are typically harder for students to discover on their own, such as algebra and computer programming.[8] Students may learn more from lab assignments when these are part of explicit instruction in critical science concepts and methods.

Clearly, specific research is needed to determine which populations gain and lose from constructivism and how its beneficial concepts can be put to best use. Perhaps certain methods take longer but result in more complex and durable knowledge. However, there is no evidence to help make this determination. At this point it seems that constructivist methods may work better for middle-class children who may have more cognitive resources and home support available if they falter. For the poor, different approaches may be more useful. Nevertheless, if poorer students automatize basic skills in grades 1 and 2, then higher-order skills and discovery-oriented learning may be carried out more efficiently.

The Pros and Cons of "Direct Instruction"

Since the early 1980s, school districts in the United States with low-scoring populations have been using a method that might be considered the antithesis of constructivism. "Direct instruction" can be traced back to behavioral analyses of decoding tasks and process-product analyses of teaching.[9] Direct instruction is a highly structured teaching approach designed primarily for elementary schools. The program features scripted lesson plans, fast-paced instruction with rhythmic group and individual responses, detailed teaching of individual skill components, and a sequence of skills based on extensive research and field-testing. The intent is to accelerate the learning of poor students as much as possible. Reading instruction may combine detailed training and color coding to teach phonemic awareness and phonics. The coding helps to normalize a bit the spelling of English words.[10] Math instruction utilizes automaticity and explicit explanations of calculations.

Direct instruction and other scripted programs (for example, "Success for All") have been the subject of many evaluations, mostly positive. The results are particularly encouraging for the early grades, with effects diminishing as age increases.[11] In the schools of Baltimore, Maryland (U.S.), improvements in math computations were dramatic, although improvements in math concepts were slight, and reading progress was moderate.[12] In other cities, such as Milwaukee, Wisconsin, direct-instruction students scored below other students.[13]

In cognitive terms, the activities seem effective. The students' attention may be maintained by the need to repeat, and they use their memorizing facility to form complex speech patterns that they do not usually hear or use at home and connect concepts that perhaps they did not learn in their family environment. Words embedded in richly elaborated sentences are more memorable (Annex section II), and the advantages of reading fluency are well understood (Chapter 5). The method focuses on small units and on frequent evaluation of achievement. Extensive teacher training is required, but scripts may also help teachers with limited education carry out the work, if supervision is effective. Peer tutors or older children might also read the scripts to younger students.

Direct instruction is promoted by the U.S. "No Child Left Behind" initiative and has drawn criticism from opponents who find it mechanistic, detail-minded, and teacher-directed with little input from students and believe it teaches reading in "unnatural" ways.[14] It may be hard to develop scripts that can work effectively for all children and all teachers. Some educators also find it unethical to prescribe such a method for poor children while advocating discovery-oriented methods for those who are better off. Direct instruction is little known outside North America and seems to have been implemented only in some schools of Liberia and Micronesia. However, it deserves experimentation in the schools of low-income countries, particularly for lower grades and for preschools.

Policy Implications

Instruction is often considered a detail that may be left up to local governments and consultants. However, ineffective teaching can be costly and disappointing. Governments and donors should become informed and demand testing and evidence before investing funds on various methods.

10
Use and Wastage of Instructional Time

Learning Essentials

Governments pay for teachers' salaries, buildings, and materials, and expect 100 percent of the invested time to be used for teaching. But often only a fraction of instructional time is used to engage students in learning. Expensive school time may be used very poorly when teachers are absent or students must spend most of the class time copying due to a lack of textbooks. Increasing instructional time is key to achieving Education for All. Setting clear achievement goals for each grade and supervising goal implementation closely may improve the use of time in school.

Visitors to schools of lower-income areas are often struck by the limited time students spend learning. Schools are sometimes found closed or teachers are late. Children may play in the yard until teachers see the visitors and call the students in. The schools of the poor offer significantly less instructional time, and it is hard to impart basic skills under such circumstances.

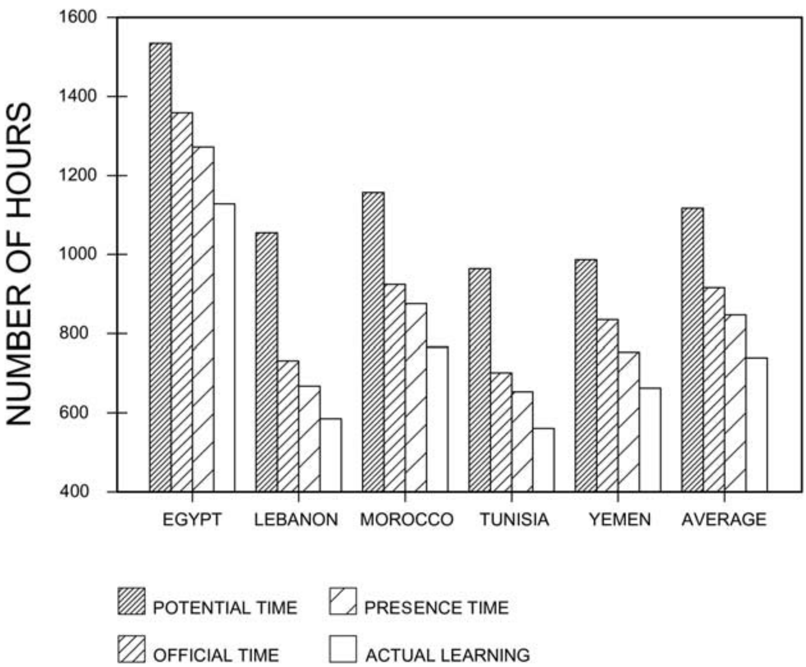
Imagine a factory that is closed 20 percent of the time, whose workers do not show up another 20 percent of the time, that lacks raw materials 30 percent of the time, and produces defective items 40 percent of the time. No investors would finance such a business, but governments finance grossly inefficient schools all the time and may fail to notice it. How does this happen and what can be done?

Schools Open fewer than the Official Number of Days

The 2005 United Nations Educational and Scientific Council (UNESCO) EFA Global Monitoring Report recommends that schools be open 850 to 1,000 hours annually, and the Education for All Indicative Framework expects at least 850 hours. Education ministries define the number of days or hours that schools should function and expect primary schools to be open for about 880 hours to 1,200 hours per year, or for about 200 days at 5 days per week, but calendars vary. In Pakistan and Nepal, the primary school year lasts for 180 days, rising to 190 days in Zambia, 200 days in Bangladesh, and 220 days in India. Several East Asian countries provide more than 1,000 hours of teaching.

However, time can be compromised due to strikes, long matriculation periods, inservice teacher training, and climatic conditions (Table 10.1). For example, in Mali, schools were found to function 70 percent of the official time.[1] In Honduras, schools were open 114 days of the official 200 in 2001.[2] In Bangladesh, some primary schools close for a month at a time to serve as examination centers for older students.[3] Surveys in Nepal suggest that schools operate on average for three hours per day, a fact that halves the teaching time available from over 1,000 hours to just 540 hours.[4]

Figure 10.1. Instructional Time Indicators in Basic Education of Some Middle Eastern Countries



Sources: Amadio 1997, Millot and Lane 2002.

Table 10.1. Instructional Hours in Francophone African Countries Implementing "Split-Shift" Schooling

Type/No. of hours annually	*Mali*	*Guinea*	*Senegal*	*Côte d'Ivoire*	*Burkina Faso*	*Average*
Standard classes	888	747	675	754	858	784.4
Double shift classes	645	585	547	580	603	592
% difference	37.7%	27.7%	23.4%	30%	42.3%	32.2%

Source: Kyeh 1999.

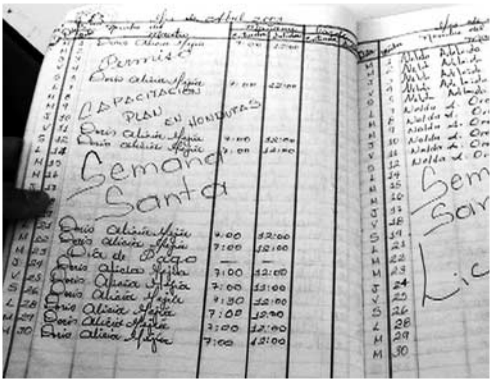
Reduced class hours to accommodate more students. Countries like Senegal, Guinea, Bangladesh, or Niger that traditionally have had low enrollments often have over 100 students in a class. In areas of teacher scarcity, class time may be split in two shifts to accommodate more students (Chapter 13). Thus, a school day of five periods may be reduced to three. In multigrade classes, common in small rural schools, students share the class but get only a fraction of the teacher's time. Predictably, split-shift classes have lower test scores. In Guinea, students from such classes scored 3.6 percentage points lower in French and 5.6 points lower in math.[5] An additional consequence may be higher teacher absenteeism, since this scheme is demanding and repeating the same information to multiple sections is tiring.[6]

Teacher Absenteeism

Like all other workers, teachers must be absent from work sometimes. Absences may be due to second jobs, health problems, pregnancy, housework, assignment away from home (therefore travel every weekend and effective teaching for 3–4 days a week), travel to collect salary, and training or educational leave (Figure 10.2). Teachers may also be entitled to lengthy leave periods during the school year (such as a total of 1.5 months in Sri Lanka). Teachers may come late or dismiss class early, thus shortening students' engaged time even further. Schools typically lack resources for substitutes, so classes are either dismissed or are partly attended by other teachers.

During a 2004 World Bank study, surprise visits were made to schools of several countries. One would normally expect 5–8 percent of all teachers to be on some type of authorized leave, so absence rates above 10 percent would be considered as excessive. Peru performed the best with a teacher absence rate of 11 percent, and Kenya and Uganda the worst with 27–28 percent (Table 10.2).[7] The average teacher absence rate in primary schools of Bangladesh was 15.5 percent. Absenteeism was highest among

Figure 10.2. A Teacher's Class Book in Honduras Showing Absences for Leave and Training before School Closed for Holy Week



Source: Author.

headmasters; one out of every five headmasters was not found in the school during the survey. Cross-sectional averages mask the extent of this problem; 23.5 percent of primary school teachers were absent during at least one of the two visits. Though salaries are often blamed for absenteeism, teachers with higher salaries were more likely to be absent.

Studies from Indonesia, Nigeria, Zambia, Ghana,[8] and Lebanon have found similar effects. Teachers are likely to be absent 25–30 percent of the time or work fewer hours.[9] An Indian survey of primary schools in India found that 25 percent of teachers in government primary schools were absent on a typical day.[10] Male teachers, older teachers, more educated teachers, head teachers, and those who lived farther from the school were more likely to be absent. Teacher absence in private schools was only 2 percentage points

Table 10.2. Provider Absenteeism Rates by Country and Sector

	Absence rates (%)	
	Primary schools	*Primary health centers*
Bangladesh	16	35
Ecuador	14	—
India	25	40
Indonesia	19	40
Papua New Guinea	15	—
Peru	11	23
Uganda	27	37
Zambia	17	—

Source: Chaudhury et al. 2004 [Authors' calculations from facility surveys, except for Papua New Guinea (NRI and World Bank 2003) and Zambia (Habyarimana, Das, Dercon, and Krishnan 2003)].

— Not available.

lower than in government schools. Contract teachers operating outside of normal civil service rules had similar absence rates to civil service teachers. The World Bank study showed that *schools with better infrastructure had lower teacher absence, as did those that were near a paved road, and those that did not practice multigrade teaching. Teachers in schools recently inspected were less likely to be absent*. There was no significant relationship between absence rates and whether the teacher was from the area where the school was located or how long the teacher had been posted at that school. Also, the existence of a parent-teacher association was not correlated with lower absence.

Teacher absenteeism is related to lower student test scores in primary schools.[11] A 5 percent increase in the absenteeism rate of teachers who stayed with the same class for two years reduced student gains by 4–8 percent during the year. The size and precision of these estimates was the same for both math and English.[12] In India schools with high teacher absence also had lower student attendance and test scores, although the relationship was not very strong.[13] Teacher absenteeism is particularly costly to the poor. Since most cannot afford private tutors, they may not be able to cover the curriculum and pass high-stakes examinations.

Student Absenteeism

Generally, attendance rates depend on pupils' opportunities to learn,[14] and if the school does not teach much or the teacher is absent, students may also come less often. In Guatemala, for example, attendance was found to increase when students received a scholarship, went to larger schools, or had an indigenous teacher.[15] Family issues and a need for children's labor are important factors,[16] but also older students and those reporting more fights at school are more likely to be absent.[17] Mistreatment and sexual harassment are related to absenteeism, particularly among girls.[18]

Absenteeism is high in programs that offer incentives for enrollment but give students little instructional support. Those unable to keep up with the class may just attend some of the time in order to stay enrolled, as in the Female Secondary Assistance Program of Bangladesh, where attendance was about 56 percent.[19] Similarly, in Niger, where promotion to the next class is almost automatic, students unable to read may stay enrolled and occasionally go to class in order to get school food. The students most likely to be absent from a class on a given day are often academically weaker. U.S. studies[20] suggest student absenteeism may also be due to boredom in classes devoid of materials and a lack of comprehension by students falling behind.

Wastage of Class Time

Other things being equal the more time students spend learning something, the more they are likely to recall it. The connections among nerves that get activated often are reactivated more easily (Chapter 3). Students in efficient classrooms may be engaged 90 percent of the time, but in lower-income countries students may be engaged only about 25 percent of the time. Even less time may be spent engaged with material appropriate for students' level and curriculum (Chapter 8). Considering all opportunities for instructional time loss, wastage of class time is often the biggest block. School effectiveness studies suggest a sizeable effect of time usage (Table 10.3).

Some teachers are willing to spend more time with students, and differences across classrooms may be striking, particularly for children with low initial reading scores. For example, in OECD countries, some first-grade teachers spent as little as 43 minutes on language arts while others devoted over 104 minutes per day. Extrapolating to an academic year, some children received as much as 180 more hours instruction in language arts compared to other children.[21] Similar results were seen in a Peruvian study, where some low-income schools taught much more reading than others.[22]

Sometimes schools operate far less often than expected. A 2003 ethnographic study on instructional time study of eight low-income schools in Bangladesh found the following:[23]

- The schools operated 19 to 55 percent fewer days than scheduled in the school calendar. One month of contact time with students at the beginning and at the end of the school year was sacrificed to administrative and nonteaching activities.
- Rural schools seldom opened at the expected time; they allowed travel time for nonresident teachers and gave a 1.5 hour break to students attending Koranic school. They did not keep classes open later, however. Male teachers had to do work elsewhere and female teachers had housework.

Table 10.3. Studies Relating Time Use and School Effectiveness

Dimension of effective schooling	*More effective schools*	*Typical schools*	*Less effective schools*
Interactive time on task	51%	43%	37%
Total time on task	76%	64%	52%
Classroom management (1–5)	4.05	3.15	3.07
Quality of instruction (1–5)	3.73	3.39	2.89
Social psychological climate (1–5)	3.75	3.61	3.48

Sources: Multiple studies (Crone and Teddlie 1995; Stringfield, Teddlie, and Suarez 1985; Teddlie, Kirby, and Stringfield 1989; Teddlie and Stringfield 1993).
Note: Time on task (ranging from 0–100 percent) was measured through the Stallings' Classroom Snapshot. The Virgilio Teacher Behavior Inventory was used as the measure of classroom management, quality of instruction, and social psychological climate; range is from 1 (poor) to 5 (excellent).

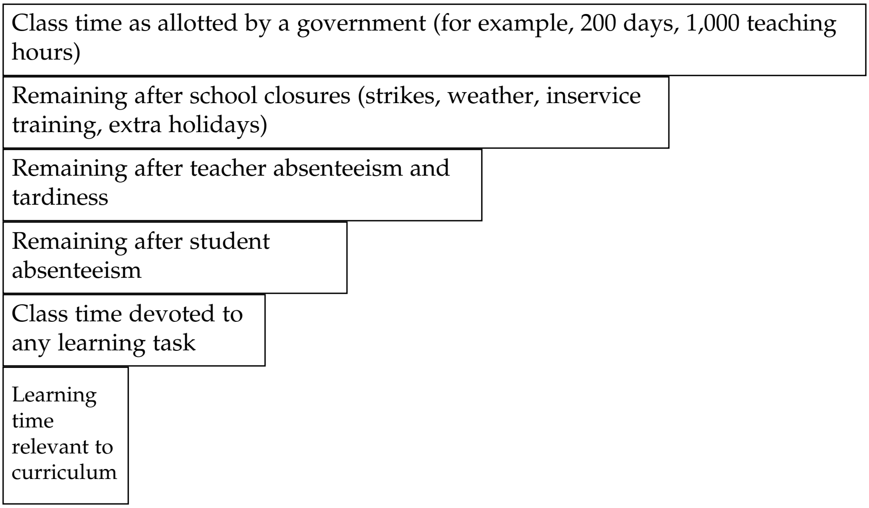
- Estimated contact hours for double-shift schools fell far short of the contact hours estimated for 2003, with contact hours for grades 1 and 2 at best totaling 419 (out of 654 hours or 64 percent of the prescribed time) and contact hours for grades 3 to 5 at best totaling 729 (out of 932 hours or 78 percent of the prescribed time).
- Only 43 to 67 percent of the enrolled students were in attendance on the days of surprise visits. Teachers estimated that only about 50 percent of the children were very regular in their attendance.
- Over 40 percent of the students in the studied schools reported having left school early at least one day the previous week. Some left after they had received food in schools with school feeding programs.
- Teaching occupied on average 63 percent of the class time in the classes observed. Lecturing occupied about 83 percent of that time.

In the surveyed schools, therefore, students were at best engaged in learning 40 percent of the time in grades 1 and 2 and 49 percent of the time in grades 3 to 5. Given student absenteeism of about 55 percent (not counting early departures) students used at best 22–24 percent of the educational time provided to them by the government. Clearly, little learning can take place under these circumstances.

Governments and other stakeholders pay for teachers' salaries, buildings, and materials in expectations that these investments will be fully used to educate students. With instructional time wasted in multiple ways, governments often do not get their money's worth from public schools (Figure 10.3). Low time use of public schools distorts educational finance indicators. If only 15 percent of available time[24] is used for learning in a country and the percentage of GDP devoted to education is 3 percent, donor community initiatives to increase spending to 5 percent are tantamount to asking for more wastage. *When teaching in effect becomes a part-time job, salary structures are skewed and teachers are paid more per hour worked than governments believe.* The reduced number of hours teachers teach in reality (including being scheduled for a lower number of hours) is also an implicit salary increase.[25] Donors often assume that certain salary levels constitute adequate teacher pay (often quoted as 3.5 times the per capita GDP) but in some cases, this is payment for part-time work. It is unclear what minimal salary levels are really needed in various countries to allow teachers to engage full-time in teaching.

Also, the wastage creates more demand for schooling by those who manage to stay in the system. Repeaters need more schools and teachers, while promoted students must go on to higher levels of schooling until they learn basic skills. For example, it takes 10 years of basic education in Guinea to get skills sufficient for vocational training.[26] Time wastage may

Figure 10.3. Instructional Time Loss Model



Source: Author.

be one reason why educational expenditures have tripled in the last three decades while student performance has not improved.[27]

Wastage of instructional time seems to be a universal phenomenon with systematically operating factors that have not been researched thus far. It is unclear why so much time can be wasted. Studies such as those of lower-income schools in Bangladesh suggest that in some areas there may be little interest in carrying out school activities either by teachers or students. The implication is that merely establishing schools and hiring teachers will not automatically result in the expected teaching patterns. The disincentives for using time productively must be understood much better.

Policy Implications

Instructional time wastage constitutes systemic inefficiency and signals the need for better governance and systemic reform. Actions to increase instructional time include strengthening the supervisory chain from central to regional to school levels, training and feedback for teachers and principals on use of time, and empowering communities to monitor teacher activities (as has been the case in Honduras and El Salvador, Chapter 14). Suitable communication strategies are needed to convince educational authorities and the public of the need to take action.

The macroeconomic implications of teaching as a part-time job with hidden salary increases must be clarified and dealt with. Sometimes the view is expressed that teachers are paid so poorly that more cannot be demanded of them. If so, policy decisions must be made on whether there should be many poorly paid teachers who work part-time or fewer and better paid teachers working full-time.

Strong political will is required to tackle the issues involved in time wastage. The main challenge is negotiations with teacher unions that governments are loath to undertake. Unions demanding more benefits may get concessions on leave policies, and teachers may be legally absent from school 1–2 days per month, despite a lack of substitute teachers. Teachers represent a large wage bill for any government and their strikes cause severe political problems. Few countries dare to fire noncompliant teachers or even hold them accountable.

Some countries consider policies of extending the school year or duration of the day.[28] It is much more economical to use existing time more efficiently. The following are some recommendations from the Chaudhury et al. studies (2004) in reducing absenteeism:

- *Increasing the frequency of inspections*. In different sector-country combinations, lower absence rates were associated with either the frequency of visits in the facility's district or the facility's proximity to a supervising ministry office.
- *Improving working conditions, especially facility infrastructure*. If a facility with better infrastructure quality makes a teacher feel better about the work environment, it can provide a positive marginal incentive for attendance.
- *Investing in rural nonschool infrastructure, specifically rural roads*. There is some evidence across countries that teacher absenteeism is related to accessibility. Thus, certain levers to increase accountability within the education and health sector lie with different line-ministries and require cross-sectoral coordination.

Research Needs

Very little research on instructional time has been carried out in low-income countries. There is a need for effective implementation modalities. Little is known at this time, for example, of the communication strategies needed to change sustainably the behavior of many poorly trained teachers who have experienced poor time use through their school years (Chapter 15). Culturally suitable models of time usage may be created and audiovisually presented to teachers as options to consider.

11
A Textbook for Every Student to Take Home

Learning Essentials

Textbooks are necessary, particularly for the poorest students. They must be provided for home use and for all levels, including secondary and higher education in sufficient quantities, even if they are lost or destroyed. Purchase or rentals for post-secondary students must be arranged through agreements with foreign and local publishers. Support for local printing industries is needed that may include tariff relief on paper and ink.

Textbooks present in a concise and structured form the knowledge that governments and other stakeholders want to impart. Compared to the investments made in infrastructure and salaries for conveying this knowledge, textbooks are a minor expense. Students are more likely to learn the material if they have it conveniently available for study, and younger students can get sufficient reading practice most easily through textbook use at home. This is why donor-financed projects usually finance reading materials (textbooks, library books, supplementary reading books).

Textbooks increase the efficiency of educational systems. Several studies of the 1970s and 1980s showed the positive effect of textbooks on achievement, particularly for poorer students.[1] For example, provision of textbooks in a Nicaraguan study narrowed gaps between rural and urban students,[2] and in Ghana textbooks helped improve test scores.[3] Guinean grade 4 students who reported owning textbooks scored 2.4 percentage points higher than average in French and 2.2 points in math. Those who reported that they read sometimes scored 12 points higher than average in French and 6 points in math.[4] The books parents have at home function as "social capital" and provide time reading practice.[5] According to the 2005 EFA Global Monitoring Report, textbooks have a strong impact on learning although they account for only a small percentage of education spending.

However, donors and governments may not clearly understand the benefits of textbooks, so they may finance them just for classroom use. This often happens in poor countries, where unit costs must be minimized to increase access. For example, in Niger, one textbook is procured for every two students in grades 4–6 in some subjects, just at the time students should be acquiring knowledge from home study. Since better-off families can buy textbooks, restrictions on use affect the poor disproportionately. Textbook rental schemes exist in various countries (for example, in Moldova), but are complex to run and may not be sustainable (as in Guinea).

No study was found that directly compared the effects of books at school with books taken home, but the book ratio for class use was debated extensively in the 1980s and early 1990s. Studies showed that when textbooks are destined just for class use, it matters relatively little whether students share a book or each has one. For example, an evaluation in the Philippines compared performance in two classes: one with a textbook for every two students and another with one textbook for every student. The evaluation concluded that textbook provision greatly improves test scores, but that there is no advantage of a one-to-two ratio over a one-to-one ratio.[6] Similarly, randomly provided books in rural Kenyan schools were used extensively but had little effect on dropout rates, grade repetition, or differences in test scores after a year.[7] The studies were mainly econometric and did not measure whether students could read fluently or understand enough of the language to obtain information from books. Furthermore, losses may effectively leave only one textbook for every 3–4 students, and teachers cannot use them in class unless they exist in sufficient quantities.[8] Without enough books, the texts must be written on the blackboard, and much class time must be spent on copying. Also, committing material to memory becomes an important skill. It is not surprising, therefore, that the ability to recite a few facts is still the hallmark of successful education in many low-income institutions.

Not surprisingly, those who may benefit the most from textbooks that are available just in class are often the better students. In the Philippines study, one-to-one textbook provision slightly improved the scores of the top 20 percent of the students; in the Kenyan study, top students showed higher test scores. Similarly, a study involving the use of flipcharts in Kenya found that providing textbooks increased test scores only among students who had scored in the top 40 percent on pretests; textbooks did not affect scores for the bottom 60 percent of students.[9] The results suggest that better students could read more material in the brief periods when they had the textbooks and understood them better. Halting readers who did not know the language well probably got little information from them.

When donors and governments finance free textbooks, they do so mainly for primary schools. Students of higher levels, including students of teachers' colleges, are often expected to take notes or go to libraries. Thus, instructional inefficiencies continue at higher education levels, as teachers must write on the blackboard or dictate complex material to students. Entire cohorts may go on to secondary and higher education by studying just notes. But notes are brief texts and cannot be remembered as easily as more elaborate sentences of books (see research in Annex II-D). And students going through school with limited exposure to texts continue to read slowly and cannot process the large amounts of print that the digital age requires. The amount of reading is related to the amount of knowledge people get,[10] and often the poor remain in a permanently restricted state of knowledge.

These problems are exacerbated by textbook scarcity in lower-income countries. During school visits, schools are often found with few if any textbooks. Reasons may include lengthy procurement delays, corruption, political disagreements, misguided views on learning, and government tendencies to skimp on books to pay teacher salaries. When textbooks are scarce and procured from abroad, there may be large-scale thefts and market diversion of free books destined for schools (in African countries but also Haiti and Bangladesh). The answer may be to spend more money and flood the country with textbooks so that their market prices drop and incentives for selling the books disappear. The additional cost may be worth the benefit. Local-language textbooks rarely if ever are reported stolen in Africa. This is one more reason why local languages should be used early in children's studies.

Not all textbooks are well-suited for efficient information processing. Cognitive research (Annexes II-B, II-D) and experience worldwide suggest that textbooks of all levels should have the following attributes:

- rich, extensive explanations and elaboration of concepts with complex sentences
- pictures and drawings for the important concepts for dual coding
- lots of practice, exercises for elaboration
- emphasis on meaning, applications, and utility for efficient categorization
- linkages with material covered earlier
- sufficient volume of material for practice and complex language use

Supplementary materials are needed for additional reading practice and to offer students different permutations of words. Students must be able to take these materials home and practice reading, even if the materials are lost. A suitable amount of material is important because if books for younger children have too few pages, the children learn may learn passages by heart and not have enough material to practice reading. In countries where computers are affordable, their use in offering practice and deepening student knowledge is invaluable (such as the Enlaces program of Chile).

Is there a benefit in textbook choice? World Bank projects in middle-income countries often include components to offer a choice between two or three textbooks. No research has been found clearly documenting the benefits of textbook choice. However, this policy may increase the cost of textbooks. Not only is the development and vetting process more complex, unit costs may increase. The publishers are likely to have smaller book runs to print, and distributions of multiple textbooks may create unforeseen complexity. Textbook choice might be advisable only in countries that already have a developed publishing industry.

Policy Implications

Textbooks for all to take home. The cost of textbooks is small compared to teacher salaries and opportunity costs. Governments and donors should not finance textbooks just for primary schools, as is currently the case. Even if they are loose-leaf desktop publications, they are needed for students of all levels. These include secondary schools, teacher training colleges, vocational institutions, and universities. Cost-sharing, repurchases, and sustainable textbook rental schemes may be effective means to get them for all students. Given the cost of information restrictions on the poor, liberal allowances should be made for losses and replacements.

12 Improving Instructional Support

Learning Essentials

Instructional efficiency depends on many factors outside the classroom that may be poorly understood. Often opportunities for efficient homework are lost. Poor children may face stress levels that impair information processing. And despite assumptions to the contrary, the physical condition of school buildings influences people's willingness to work inside them; noisy, cold, esthetically unappealing schools in poor condition may be costly in terms of student and teacher performance.

This chapter presents research highlights on some of the many factors that directly or indirectly influence the quality of instruction. Significant topics include homework, curricular dilemmas, the quality of decisions based on testing, students' emotional problems, and the effects of school buildings on learning.

Classroom "Climate" and Student Achievement

The relationship between emotions and recall is that of an inverted U. Humorous and expressive teachers make learning more memorable (Chapter 4) and help create an environment that may encourage students to show up and stay in school. Praise at unexpected intervals is much more reinforcing than constant positive feedback, as conditioning research showed in the 1960s (Annex I-C).[1] Moderate stress levels engage people[2] and may facilitate recall. For example, pre-exam stress was found to help college students accurately recall a list of memorized numbers, although it reduced problem-solving abilities that required flexible thinking.[3] Emotion research also highlights the ability to control one's impulses and delay gratification.[4]

Self-regulation and ability to withstand stress are associated with higher achievement in standardized tests[5] and improved capacity to deal with the social environment.

When a problematic situation personally affects students, however, the stress may rise enough to inhibit learning and distract attention. Upset, abused, or worried students may show impaired consolidation.[6] The poor face many stressors, particularly in post-conflict countries such as Afghanistan and Sierra Leone, where many students may be suffering from post-traumatic stress syndrome. Where incidence of AIDS is high, orphans or children taking care of sick relatives may be depressed and less able to remember material. Teachers often lack the training and time to deal with the emotional issues of large numbers of students, and they may be under significant stress themselves. Some teacher behaviors adversely affect students. Studies document the physical, emotional, or sexual abuse that students may suffer in the hands of teachers, who may also speak derogatorily about them in their presence. Girls in particular may be sexually harassed by male students and teachers. In Cameroon, for example, UNICEF reported that teachers had had sexual relationships with 27 percent of the girls surveyed.[7] Negative experiences in school may shape attitudes against it not only for the students but for their own children as well.

Overall, dealing with emotions in the schools of lower-income countries is difficult, partly because the actions to undertake through country dialogue are unclear and more applicable at the personal than at the policy or country level. One policy may be to teach conflict management in war-torn and post-conflict reconstruction areas.

The Case of the Missing Homework

Homework could be thought of as an extension of engaged time. It should reinforce the material taught during the day and facilitate consolidation and reconsolidation (Chapter 4). Furthermore, material that is studied before going to sleep may be remembered better than material studied earlier in the day.

U.S. studies have shown benefits for students doing homework and supervised study time at home. However, little is known about the quantity, content, and frequency of homework in many lower-income countries. In the few countries where some data are available, the effects are unclear but tend towards positive outcomes.[8] For example, Guinean students who reported doing homework scored 7.6 percentage points higher than average in French and 9.8 points higher than average in math.[9] However, research on the PASEC scores (Programme d'analyse des systèmes éducatifs) suggests a nonsignificant effect.[10] Analyses of TIMSS data

(Trends in International Mathematics and Science Study) often find little relationship between the average amount of homework assigned in a nation and corresponding level of academic achievement.

The ambivalent results have multiple explanations. Parents with limited or no education cannot help children, particularly if they study in a foreign language, so students who need extra work and drill the most may be the ones least likely to get it. In better-off homes, on the other hand, busy parents may not welcome homework.[11] Also, teachers may be unwilling to spend time correcting the homework and giving feedback.

Homework practices and options must be explored more systematically. Experimentation is needed in low-income schools with various assignments, textbook use, and duration.[12] One modality to try out would be after-school programs, which in the United States are very cost effective.[13] (Older students could be engaged to provide practice to younger students and tutor them.) Hopefully more systematic attention can be paid to the homework opportunities for increasing instructional time.

Curricular Effects on Student Achievement

The World Bank and other donors have financed for years development and reforms of curricula. Efforts have been made to make them relevant, integrated, competency-based, and gender-sensitive so that they would provide knowledge, skills, and attitudes that a country needs. Nevertheless, the contribution of curricular exercises to improving education quality is unclear. Curricula take years to develop, require considerable outlays in teacher training, and ultimately they are interpreted by teachers who may know little about their intent. After the 1980s, the Bank financed curricula mainly in the former Soviet Union countries.

Curricular development is beyond the scope of this document. But curricula in effect structure cognitive networks (see Annex II-B), and memory research has some implications for the most efficient and durable configurations of these structures. Consolidation and reconsolidation processes favor "spiral" presentation of material over various grades.[14] Repeated presentation in increasing detail can take advantage of the brain's ability to edit information that has been recalled while attaching new information to it. However, presentation timings might be adapted to the rate of forgetting and reconsolidation for various types of memory. These issues have not been studied in detail, and there is a need for such educationally based neuroscientific research.

Curricula often reflect the learning needs and rhythms of the urban middle class. Thus, they are loaded with myriad activities for the first few grades. Predictably, few schools serving the poor reach the end of the textbook—if they have one. The need to spend time on basic skills in the lower grades often runs against competing priorities. IEG discussions with officials have sometimes shown that the curricula are driven by what foreign universities are likely to demand for entrance from the graduates of low-income countries. This is hardly a means to determine what poor students should know to help poverty alleviation.

The large number of courses taught in many countries (particularly at the secondary level) raise the concerns about students' ability to consolidate some topics that may be presented just once. To enable more students to master curricular content, reductions in volume and prioritization may be needed in some cases. However, political risks may arise if middle-class parents believe that schools are not sufficiently challenging. National debates are needed to determine what students really ought to know and how the needs of all can be met. Means must be found to highlight effectively which skills are critical for subsequent study—and needed for all students—and which ones have lower priority.

Music and the academic performance of the poor. Art and music are known to develop valuable skills, including spatial perception and verbal memory. Music training brings about cortical reorganization in the left temporal region. The more music training stimulates the left brain, the better that side can handle other assigned functions, such as verbal learning.[15] Brief exposure to certain Mozart pieces may also improve memory performance for a short period of time.[16]

Children in the United States who studied music for a school year showed greater increases in intelligence quotient (IQ) from pre- to post-test than children who did other activities. Generally these increases occurred across IQ subtests, index scores, and academic achievement. By contrast, children who studied drama exhibited improvements pre- to post-test in the area of adaptive social behavior, an area that did not change among children who received music lessons.[17] Chinese research showed that students with six years of musical training recalled significantly more words than untrained students, and they generally learned more words with each subsequent trial. Plus, the longer the training, the better was the verbal memory.[18] Students with better verbal memory probably will find it easier to learn other subjects in school.

Music education is rarely a part of the curriculum, especially in low-income countries. The expenses and expertise required for it are often too high. However, it has been shown in Venezuela that music has significant effects for children who are at risk (Box 12.1). Middle-income countries, such as Uruguay or Tunisia, may be able to reach at-risk children through this modality. Countries with indigenous music traditions might also benefit from the effects of group work towards a performance-oriented goal

Box 12.1. Youth Orchestras for the Poor in Venezuela

In the late 1980s, a charismatic piano teacher started the formation of orchestras to teach music to children of poor neighborhoods. The initiative spread all over the country and resulted in over 200 orchestras reaching more than 150,000 children and youth. The intellectual benefits have been evident. The youngsters willingly practice 3–4 hours a day, learn discipline and social harmony, and find an escape from the problems plaguing low-income areas. Though some cannot read books, they find little difficulty in learning to read music fluently. Program results included fast learning of instruments, with an orchestra able to perform Handel's Hallelujah eight months after its formation. The program is credited with reduced dropout rates for students and improved self-esteem and cooperative behaviors.

In 1997, the Inter-American Development Bank in Washington, D.C. gave a US$8 million loan to support the Venezuela National System of Youth and Children's Choirs by financing a music teaching program and the construction of a headquarters building in Caracas. The orchestras have performed world wide, earning acclaim and community pride. Young musicians got opportunities for professional work. Nearly every Venezuelan state has a professional symphony, and musicians earn as much as US$800 a month. Thousands more are employed by the State Foundation for Youth and Children's Orchestras.

Source: Johnson 1998; IADB loan no. was VE-0105.

and reap the neurocognitive benefits of music education for some of their students.

Effects and Interpretation Difficulties of Achievement Tests

Multiple-choice sample-based assessment testing is often the instrument used to measure what students are learning and to inform policy with respect to learning outcomes. Since the 1990s, countries receiving donor aid have gone to great lengths to develop multiple-choice achievement tests, and results from many have been available since the mid-1990s. In addition, there are several multicountry assessments as well.[19] These are often given in grades 4–6, because of limited reading skills in earlier grades.

As mentioned in Chapter 1 (Table 1.1) scores in many countries are shockingly low, even though many poor students have dropped out by the upper primary grades. However, the scores have had little practical use in policy adjustment and quality improvement. One reason is that students show major deficiencies in all areas rather than in specific areas that may amenable to remediation. Also, the scores have no intrinsic meaning and no linkages with observed behaviors. Typically they refer to percentages of items answered correctly or some transformation of this metric. Thus ministers get little insight from learning that students scored 40 percent in science (except perhaps to compare scores with those of their own children.) It is also hard to track progress, since long-term comparable data are often not collected in poorer countries. A test may be given only once, or unequated tests may be given at different times, each with its own psychometric properties and unknown validity and reliability. For example, samples of students in Niger were administered three different tests between 1999 and 2003. One reason for these disparities is the technical sophistication and large expenses inherent to achievement testing; poor countries may lack such resources.[20] It may be preferable to strengthen countries' existing high-stakes tests (such as entrance and leaving examinations) that actually determine people's futures. If such examinations become more valid and reliable they may point more effectively to specific areas of weakness to remediate.

Thus, national assessments may not be the most suitable tool to assess the lowest levels of achievement in poor countries. One alternative may be curriculum-based assessments in lower grades when specific remedies can be applied. Rapid reading surveys that assess students' ability to read orally for brief periods[21] have been carried out in Peru, India, Mali, and other countries. They provide real-time information on skills that students are able to demonstrate in person, such as reading and answering a few questions (Chapter 5). Videotaping the performance of students trying to read has been shown to demonstrate powerfully the problems they face and spur officials and students to action. A public-service video offering test results and explanations of reading standards has been successfully used in Peru.[22]

The final examinations and high-stakes tests given in many countries require much studying and often private tuition. High-stakes tests often emphasize facts and procedures rather than comprehension and analysis, but they constitute powerful reasons for reviewing classroom material at the end of courses. "Cramming" for exams is condensed rather than distributed over time and may overwhelm the memory consolidation system (Annex II-B). But the tests may enable students to reconsolidate and integrate at least some of the material for long-term retention.[23] No comparative research has been found, but perhaps students in countries with end-of-cycle examinations requiring preparation (such as most European countries) have better long-term recall of school subjects than countries without such examinations, like the United States and much of Latin America. Unfortunately in low-income schools students tend to get tested less often and miss out on this consolidation opportunity.

Effects of School Facilities on Achievement and Attendance

The donor community has extensively financed school buildings. Given the large numbers needed, particularly in remote rural areas, the emphasis has been on lowering costs. Much research has also gone into mapping schools with respect to village locations and understanding the factors that impede student attendance at nearby villages.[24] Efforts have been made to use local rather than imported building materials and to use the least amount of space needed. Budget limitations and maintenance difficulties in many countries often mean that very simple buildings are designed, with metal covers on the windows rather than glass.

Local norms determine to some extent how attractive a school appears, but a building has multiple community functions, and physical appearance may be worth considering aside from sheer functionality. Classroom repairs and basic equipment have positive effects on achievement.[25] Both students and teachers are more likely to enter and stay in school if the physical environment is attractive.[26] A detailed study in Ghana has also shown that building condition influences student learning.[27] Safety and sanitation for girls and access for the disabled are prerequisites for school designs, as is the need for file cabinets and storage to deter book theft.[28] Other issues include the following:

Effect of lighting on learning. Daylight in schools is related to better student performance (possibly because of effects on circadian rhythms and the pineal gland). Students in U.S. classrooms with well-designed, adjustable skylights that diffused daylight throughout rooms and reduced glare improved their learning substantially faster than students in more traditional classrooms.[29] There may also be nonvisual effects of lighting on students, including improved dental health, physical growth, mental development, academic achievement, and attendance.[30] When schools have no electricity, lighting is much harder to control. In tropical countries, metal window covers to keep out heat make classrooms dark (Figure 12.1). Similarly, utility costs may keep schools in central Asia dark during the winter.

Size and appearance of the blackboard. Too often blackboards are small and made of material that does not facilitate easy erasure. Traces of previous writing are left, confusing many readers. Blackboard size and condition may negatively impact children with limited vision, given that many poor students with eye refraction problems may not have access to eyeglasses.

Figure 12.1. Dark Classroom in Rural Niger

Source: Author.

Hot or cold classrooms. A comfortable temperature may maximize worker productivity. For example, typists in the United States may make more errors in cold rooms. When office temperatures increased from 68 to 77 degrees Fahrenheit (20–24 centigrade) typing errors fell by 44 percent and typing output jumped 150 percent.[31] Likewise, reading and math performance have been found to decline at temperatures above 74 degrees Fahrenheit (23 centigrade).[32] The performance of students in central Asian schools that are cold in the winter and for those in sub-Saharan Africa, where schools are permanently hot, may be similarly affected. In countries like central Asia, where large dilapidated buildings must be kept airtight to save firewood in the winter, *carbon dioxide levels* may also rise, making students lethargic.[33]

Noise. To keep buildings cooler and construction costs lower, schools may have open transoms above all classes or no internal walls ("open plan"). In areas such as rural Chile, buildings with open transoms may be seen, while in Sri Lanka and rural Maldives open internal spaces are common. In the latter model, classrooms may be separated by a low wall or movable dividers. Thus, several classes may be going on simultaneously in one space, with teachers shouting and students reciting en masse.

Not all noise is equally distracting. Constant background noise or music may not necessarily disrupt attention, but intermittent or sudden noise does.[34] Voices are particularly disruptive because they enter into people's phonological loop.[35] No research has been found on this subject, but some students probably have trouble paying attention to their teacher. Children sitting closest to the next class may need to expend extra energy for attention to block out the interference. Blocking other voices may be easier if children are engaged in an interesting task, but if they sit passively, listen, and recite most of the time, it might be harder. State-dependent learning research predicts that students will perform best if the state they learned the material matches the testing state, but overall performance in noisy environments may be lower (Annex II-B). It is unknown how easily children become accustomed to the noise of other classes and how it impacts their performance. In the small group of countries that have large numbers of "open plan" schools, the effects of this building plan may be worth researching.

Policy Implications

Rapid oral reading surveys and videotapes of students reading can be powerful instruments for bringing about policy change and informing the public regarding standards to expect in school. Countries wishing to improve reading performance may produce short films for television to show the public the expected reading standards and communicate the need to monitor fluency and instruction their children receive in school.

The World Bank and other donors continue to finance schools with cost as the main determinant of design. However, schools need to be designed with more attention to the factors known to affect student performance and attendance by teachers and students. Slightly higher costs might result in significant learning improvements.

Donor financing might include strategies to increase after-hours study and homework, possibly in the form of tutoring by older peers. Strategies might also be developed to prioritize topics and reduce the demands of early-grade curricula so as to enable students who have limited instructional time to cover the basics.

13
Student Grouping and Class Size Effects

Learning Essentials

Large class sizes are not necessarily detrimental, particularly when students want to be in them, are better prepared, and are willing to cooperate. However, students cannot get feedback or attention in large classes. Grouping and cooperative learning techniques have somewhat unclear outcomes but may improve opportunities for elaboration and feedback.

For effective cooperative learning, students must have sufficient knowledge to carry out the work required. Peer tutoring also requires extra time on behalf of the tutors, who must themselves study during class time.

In multigrade classes of low-income countries, time is often divided among grades, leaving some students unoccupied. Students must become fluent readers by grade 1, or they may be unable to study the required material by themselves. Multigrade classes in resource-poor schools that also require instruction in an official language may simply be unrealistic.

Visitors to periurban schools of many countries—but also to rural schools of countries like Guinea, Yemen, Kenya, or Bangladesh—are surprised to see 60 to 100 students stuffed in small rooms, often sitting on the floor. Can students be taught effectively in such large classes?

As enrollments skyrocketed due to the Education for All efforts and the abolition of fees, many low-income countries are unable to pay the resulting wage bills. The International Monetary Fund (IMF) advises limiting the numbers of teachers, a policy that creates conflicting commitments.[1] The result is classes in urban schools of 70–120 students or more. To keep classes manageable instruction time has been split into two shifts in some countries, offering students too little instruction to benefit from schooling (Chapter 10). Since rural classes tend to be small, national class-size averages appear modest. The regional median class size in sub-Saharan Africa is 44 students, whereas in South and West Asia it is 40.[2] The indicative framework for implementing Education for All suggests an average class size of 40 for countries, a figure based on results of countries that have achieved universal enrollment (Chapter 16).

World Bank research concluded in the 1980s that a class size of 20–45 students did not affect student achievement and advised countries to increase class size.[3] However, evidence of the effects of class size is mixed. Research in industrialized countries has shown that teachers and parents are happier with smaller classes and students do better,[4] so class sizes in Europe and North America rarely rise above 30. Some U.S. studies[5] suggest that competent teachers manage larger classes better and that size does not necessarily affect test scores. Due to the importance of basic skills, children in the early primary grades are most affected by class size[6] and benefit from smaller classes.[7]

In principle, teachers can lecture to vast audiences, like university professors, but they cannot give individual attention or feedback to many children. However, mitigating factors may facilitate learning. An important factor is the social relationships among individuals and institutions in a school community ("social capital").[8] Families and students choose to be with other high-scoring students and collaborate to keep classes manageable even if they become crowded. This is one likely reason why private schools and good public schools tend to have large classes.

It is unknown how social capital operates in areas of high demand and few schools, but research suggests similar factors can help manage large classes. Seven rural Kenyan primary schools were selected for a program that provided textbooks and paid for required uniforms. The program attracted many students from neighboring schools, so overall enrollment in these schools increased by 40 percent. Achievement scores were about the same, but the dropout rate was 6.8 percent at program schools and 16.5 percent in comparison schools. The analysis suggests that increasing class size and using the funds to reduce school fees and purchase textbooks would reduce dropout rates without measurably reducing test scores.[9]

Another study made an effort to estimate optimal class sizes based on PASEC test scores in West Africa. It was shown that up to a class size of 62, additional students have a positive though decreasing effect on learning, possibly due to student self-selection. From that number on, the effect become increasingly negative, though it remained modest. In a class of 80, 10 additional students would reduce achievement by about 10 percent on average. Thus, the quantity-quality effect is not severe with respect to class size. However, splitting classes to decrease size and instructional time does have a negative effect. An optimized solution for the data of the study was a class size of about 97. The author concluded that it is not efficient to split classes into shifts for sizes below 100.[10]

The effects of large classes on teachers have not been studied. It is unclear how they deal with the noise level, even when students are well behaved and sit quietly. Teachers probably cannot keep track of so many students' performance, nor can they correct homework for so many. (Some are known to charge parents extra to correct homework.[11]) Thus, teachers may systematically pick a few good students and ignore the rest.[12] Students may still get feedback from choral answers, and they might benefit from group work in elaborating the material. However, the onus in such large classes is on students to decide whether they want to learn. Can improvements be made on this situation? The following sections show research and possibilities.

Formation of Student Groups: Learning Potential and Issues

Cooperative learning and peer tutoring are often proposed as solutions to the limited availability of teachers. Grouping may create structure in very large classes and enable the weaker students to benefit. To what extent and in what ways is this potential available and realizable? The following section summarizes pertinent research.

People form groups automatically with no prior experience. There is a biologically embedded basis for cooperative behavior that has aided human survival in evolution. Social psychology research has explored the various parameters of cooperation and competition and suggests that humans derive benefits from altruism as well as from a modicum of competition. Brain regions linked to reward processing are activated when players of simulation games decide to trust each other and cooperate, rather than betray each other for immediate gain.[13]

Social groups influence learning and interactions in various ways. What has been particularly startling to researchers, though, are the profound and immediate effects created by group membership. Groups form even on the basis of very superficial characteristics (such as badges of different colors) and influence members' behavior immediately.[14] A dominance hierarchy emerges within a group. "In-group" members favor their own and tend to ascribe negative qualities to "out-group" members.[15] Member's perceptions, attitudes, preferences, and behaviors show this favoritism in many unprovoked situations. This is true of children but also of adults (including teachers), and people may be unaware of the extent to which membership in various groups influences their behavior. For example, a teacher may be an in-group member of a community or perceived as an "out-group" member, and community-school relations may be influenced by these little-understood factors. When clear groups are formed, they may get into conflicts and competitions at little provocation, particularly with children and adolescents. Conflicts can be reduced mainly by collaborating to accomplish goals which both groups desire but which can only be accomplished when they work together.[16]

Research on cooperative learning has mainly taken place in the United States and Europe, and its results are mixed. Several studies have demonstrated the benefits of children working with other children in collective learning efforts.[17] Students serve as role models for each other; groups of lower-ability students may persevere in tasks they might otherwise stop. Students who learn in pairs may become more altruistic towards their teammates and offer social support. Social dynamics may override the usual correlation of success with positive attitudes and failure with negative attitudes. In heterogeneous groups low-ability students learned more while the learning of higher-ability students was not compromised.[18] Some research indicates that cooperation is more effective than competition and individualistic work, and that competition among student groups has better outcomes than interpersonal competition or just individual effort.[19] Students are more likely to accept others' explanations when they have asked for the help rather than when it is unsolicited.[20] When children collaborate, they share the process of constructing their ideas, instead of simply laboring individually.[21] They must agree on answers, explain their logic to partners, and summarize, using processes that constitute valuable elaboration.

However, published research tends to report on well-implemented experiences rather than the situations likely to be encountered in low-income countries. Student interactions may use up valuable class time. Some U.S. studies suggest that cooperative learning experiences are effective for high-achieving students, who contemplate the material as they explain it, but low achievers may gain very little. The latter gain more when they are taught through explicit, direct instruction. And it is unclear how students used to working through material in groups will perform procedures alone in high-stakes exercises or in real life.

Group size is an important issue. The tasks that require the most focus are best performed by student pairs, which also have the most interaction among them.[22] Tasks requiring creative answers and collaboration are best served with small group interactions.[23] Generally, the larger the group, the greater the "diffusion of responsibility" or "social loafing," particularly if motivation is limited. For example, groups of three will ask more questions and offer more opinions than groups of 30.[24] People try less hard to assess a stimulus when they belong to a team of 11 than when they are individually responsible.[25] Thus, individuals may feel less responsible in groups. This means that group sizes must be kept small, ideally two to five students. Groups of more than six students may be ineffective for instruction purposes.[26]

Figure 13.1. Cooperative Learning Techniques in Tanzania

Source: International Reading Association 2003.

A mixed-achievement heterogeneous group of one high-achieving student, two medium-achieving students and one low-achieving student may create the balance most conducive to learning.[27] But not all students participate in the same way: people seem to assume different roles. Groups consist of "cooperators" who initiate the work (about 17 percent), "reciprocators" who will cooperate if they see the utility of the task (about 63 percent), and "free riders" who will do as little as possible (about 20 percent). To be involved, reciprocators must understand that there is something to be gained through their efforts. Thus, everyone must be kept apprised of the successful contributions of others within the group.[28]

Group work is not optimal for all tasks. When given a problem, individuals may spend more time learning about it while groups spend more time in search of strategies to solve it. So when solutions have been offered before, individuals may perform better because they use their memory, which in groups is less important.[29] But when students must find novel or difficult solutions to problems, groups perform better, because they share their knowledge, bring different experiences and expertise to the problem, and keep each other from drifting off the point.

Cooperative learning in large classes. Student groups are an untapped potential for dealing with large classes; 80 students could be divided into 16 groups of 5 students that are to some extent responsible for ensuring mastery and comprehension of the material. Those seated in a front row can turn towards those behind them. One model for doing so is the Jigsaw classroom.[30] In this configuration, learning material is broken into "chunks" and distributed among the students of small heterogeneous groups. The children from each group with identical assignments form a temporary "expert" group to help each other assimilate the material. Then children re-form into their original group, and each "expert" child now has the responsibility of teaching the material to the other children within his or her group. In this manner, each child has gained first-hand knowledge of a portion of the material and second-hand knowledge of the remaining material that allows for rehearsal and elaboration.

One experiment carried out in Germany[31] showed more interaction between children in a Jigsaw classroom compared with those in the control groups in a traditional classroom. Almost all children in the cooperative groups showed better performance in the topic areas compared with those students in the control groups. This is congruent with the assumptions that the children will pay close attention to the material being presented by the other expert children in the group. It is also congruent with group interaction research suggesting that children may be aware of fellow students' misunderstandings and better able to give explanations than the teacher.[32] However, students can only transmit what they know, and there is a risk that they can also transmit errors and biases. There is also a possibility for negative interactions and social control that may push some students out. This modality may be best suited for disciplined and mature students, perhaps of higher grades.

Overall, grouping techniques depend on discipline and teacher control. IEG observations in Brazil found that some of the classrooms become chaotic with noise and poor use of instructional time, whereas in Indonesia, students formed and dissolved groups in less than a minute. Teachers need to watch time carefully and give group tasks that last for only a few minutes. Considerable teacher training is needed on the rationale for group formation as well as on creation of groups out of densely seated students who hardly have space to move in classrooms. Overall, there is a clear need for more research in low-income countries on when to use cooperative learning and when to avoid it. Students may benefit differentially from group work or "traditional" instruction depending on how well the activities are designed, goals are articulated, whether the roles of each student are clearly defined, whether students can do the work with minimal support, and how conflict between students is handled.[33]

Peer tutoring. Students who tutor others have to reconstitute material, thus elaborating it and making it more memorable for themselves. However, the benefits of tutoring younger students during school hours must be balanced against the need for the potential tutors themselves to be engaged in learning the curricula appropriate to their grade in the limited time they are in class. Furthermore, students must be sufficiently knowledgeable so that they can transmit information without mistakes. For example, in rural Niger there has been a plan to pilot peer tutoring, but students with sufficient command of reading and French and willing to work as volunteers may be nearly impossible to find. By contrast, *tutoring by teenage aides* may be more effective. A randomized trial showed that adding an extra teacher to classrooms in rural India did not improve children's test scores. But hiring high-school graduates who were paid only US$10 to US$15 a month to give remedial tutoring to groups of lagging students in a Bombay slum markedly improved reading and math skills.[34]

Students may form groups spontaneously to solve problems or copy homework, but under certain conditions they can do so over a long period of time and learn very novel skills. This impromptu cooperative learning was demonstrated through the Indian "hole in the wall" experiment, which also highlighted an interaction previously unknown between visual perception and the rapid reinforcement provided by video presentations (Box 13.1).

Economic integration of students in the same class. Low-income students may do best in middle-class schools where they are surrounded by more academically engaged peers and parents as well as better teachers than in low-income schools. So, some U.S. school districts have made concerted efforts to integrate the schools economically. In areas such as Wake County, North Carolina, school officials have used income as a prime factor in assigning students to schools since 2000, with the goal of limiting the proportion of low-income students in any school to no more than 40 percent. The plan has been feasible because the county has urban and periurban schools, there are sufficient schools to distribute students equitably, and many residents agreed with the concept. As a result, 80 percent of black students in grades 3–8 score at grade level compared to 40 percent around 1995. Similarly, 91 percent of Hispanic students scored at grade level compared to 79 percent around 1995.[35] This initiative is in some way contrary to the increasingly popular vouchers that enable individual students to move out of low-income schools to better schools. Economic integration may not be applicable often in low-income countries, where most students in public schools are poor, but it merits consideration in specific circumstances of middle-income countries.

Student Performance in Multigrade Classes

Multigrade teaching is promoted by the donor community as a financially efficient form of educating students in sparsely populated rural areas. Much has been written about this form of education, which is beyond the purview of this book. Some countries depend on this form of education, as in Honduras where multigrade schools account for about 81 percent of all schools. Studies in the United States from the 1930s through the 1980s reported advantages in terms of improved social relations, enhanced attitudes toward school, and more independent study, with few disadvantages, if any. Also, studies of the Colombian Esuela Nueva have showed lower rates of dropout and repetition.[36] Students observed by IEG in relatively prosperous rural areas of Chile and Brazil started class before the

Box 13.1. "Hole-in-the-Wall Experiment": Cooperative Learning, Visual Pattern Recognition, and Computer Use

In 1999, Sugata Mitra installed a computer connected to the Internet in a wall by a slum area in India and recorded activity with a video camera. He found that children below age 13 mainly operated in groups, learning to use and surf the Internet without even knowing English. They taught themselves to use the mouse, learned many games and programs like Microsoft Paint, searched Hindi Web sites, and removed viruses from files. Many were completely illiterate and could not understand word patterns or pronunciation; others had reading problems and low test scores in schools. Nevertheless, they could "read" the names of applications and explain their functions, even when their position on the screen was changed. They also learned many English words heard from the computer's speakers. Children found solutions in groups and taught each other.

With financing available from the World Bank's International Finance Corporation, the experiment has been duplicated in about 100 kiosks across the country. After several months of being exposed to this experience after school hours, children took and passed tests for computer literacy and English knowledge. Interviews with parents suggest that children learn to focus better after about a year of exposure to the "hole-in-the-wall" and tune out environmental noise. They may also speak more softly because they must talk in small groups. The experiment has been replicated in South Africa.

This experiment involved an interaction of an unusual set of variables: group dynamics, immediate feedback, fine motor coordination in learning to use a mouse, and public view. These are mechanisms that are not clearly understood and have not been put sufficiently to educational use. (The learning curve resembles the equation indicating the rate of a capacitor charging.) Children are willing to solve problems together because they get immediate feedback and stimulation from novel, moving visual patterns. However, participation is voluntary, so there is a self-selection bias. Seated at school computers, the average students often do not persist in learning.

Source: More information is at www.niitholeinthewall.com.

teacher arrived, used dictionaries, and explained the sequences of the tasks they were to complete from one day to the next.

Multigrade instruction involves grouping and collaborative learning by necessity. There are examples of multigrade schools in Europe where low birthrates have reduced school populations. Flexible and well-trained teachers integrate students of various ages and assign age- and grade-appropriate tasks in various subjects. However, individually guided education may not be for everyone.[37] In lower-income countries training for this complex form of teaching is limited, as are materials. Frequently teachers try to implement a monograde curriculum for each of grades 2–6. They assign seatwork to students of one grade while teaching another, and in fact give students a fraction of the instructional time. They must monitor also the work of multiple classes in relationship to curricular norms at a particular point in time, but they probably cannot realistically do so for more than two grades. Less well-educated or unsupervised teachers often do not perform satisfactorily, and students of each grade may sit idle part of the time. For example, teachers in Morocco were observed in 2001 by IEG teaching the entire class or sitting outside and leaving all grades unsupervised. Teachers in Panama and Honduras whose students clearly had not mastered the prescribed curriculum reported that the students were up to date simply because the required topics had been nominally covered.

Designing effective multigrade schools requires long-term collaboration, a team of writers, and much teacher development. To teach multiple grades efficiently curricula must be specifically aligned into units that can be taught simultaneously in a "spiral" way. It is often possible to teach a single topic at a simpler level to young children and at a more complex level to the older ones. Thus some activities can be carried out by the whole class and others by specific grades. The content and competencies can be matched in two- or four-year units that greatly facilitate teachers' work. Peer tutoring and cooperative learning are needed to use time well.[38] In some circumstances, older students might serve as tutors for pay or for prizes, if it is possible.

Perhaps the most important problem in multigrade classes is early reading achievement. To study through this mode, students must be able to read considerable amounts of material quickly, so they must be fluent readers since grade 1. Weaker readers are at a particular disadvantage because they may never get enough feedback and practice to read, so a vicious circle may develop. Since students cannot read well, they cannot benefit from the supplementary materials available in countries like Brazil. Thus the paradox develops of children unable to read in the midst of excellent reading materials. Students observed by IEG in Brazil, Honduras, and Panama could not read fluently until grades 4 or 5. In the Brazilian northeast, Escola Ativa student groups were seen trying to learn reading without help in grades 2 and 3. However, they were unable to complete a learning task that required reading; they soon stopped and started to play. Students in rural Niger also had to learn French before they could do independent work and had to do so without textbooks or much teacher interaction.[39] Schooling may simply not be possible under some circumstances.

Multigrade classes in poorer areas require intensive supervision and extra instructional time. By definition, many such classes are in remote areas, where supervisors rarely go and the local population has limited education. Such arrangements may test the limits of what schools can do. Perhaps in the most extreme circumstances only basic literacy can be acquired in the mother tongue—and only after years of attendance.

Policy Implications

Large classes have been an inevitable outcome of Education for All strategies and the elimination of school fees in many countries. It is important to provide advice on how best to deal with them and to experiment with means to maximize instructional time and information. The advice given to some countries to split the instructional time into shifts in order to keep class sizes to around 40 students (Chapter 10) is not sound.

Cooperative learning and peer tutoring are often mentioned as solutions to teacher shortages and large class sizes, but the concepts have not been tested on a larger scale. Experimentation is needed to find out the extent to which large-scale implementation of grouping techniques is feasible in large classes. Teacher training logistics also must be dealt with.

An integrated package is needed of materials, training, support, and curriculum specifically designed for multigrade teaching. In addition, governments and donors financing such classes might pay attention to the following issues:

- very intensive teaching of reading and basic math in grades 1–2 so that students become fluent readers and will be able to learn from books on their own
- getting help from persons available in the community, either voluntarily or by remuneration, using peer tutors after-hours
- training teachers on multigrade models that are easy to implement given the limitations of rural schools
- easy record keeping methods and curricular calendars to keep teachers oriented
- regular supervision of multigrade classes and verification that students are indeed covering the required material
- discontinuing multigrade classes in very poor areas as soon as conditions permit it, such as by consolidation of small schools when transportation becomes convenient

PART III

Performance of Teachers and Educational Systems

14
Teacher Incentives and Motivation

Learning Essentials

People tend to work for intrinsic incentives rather than just money and are more likely to respond to consistent supervision, clear administrative linkages, and praise for a job well done. Teachers often work unsupervised in tasks that have no clear deadline. Teaching may appear to some as a never-ending task and confound the reward mechanisms of the mind. The challenge is to break down teaching tasks into subgoals and small steps that can be effectively supervised.

Effective incentive structures are needed to help teachers do their job. Research suggests that intrinsic rather than extrinsic incentives work better, but for the very poorly paid teaching profession financial rewards may also be effective. Community control and incentive mixes that reward good teaching rather than just test performance may help increase accountability.

Everyone involved in educational systems says that teachers should teach, principals should oversee them, and inspectors should inspect. Why they do not in so many circumstances is unclear and poorly understood. Neuroscience is still unraveling the reward system of the brain and has not produced many answers applicable to teaching. To shed some light on teacher performance issues, this section presents the highlights of psychological research on motivation and the related concept of accountability.

Motivation and Incentives—Extrinsic and Intrinsic

Motivated behavior may be recognized easily, but it has been hard to define and to improve. It is directed towards a goal and persists until it is achieved.[1] When people are motivated, they are alert, they pay attention, and their recall improves.[2] Human behaviors nearly always have multiple motivators.[3] Motivation is considered intrinsic when the incentives are internal—that is, cognitive or biological (such as curiosity, search for understanding, or hunger).[4] It is considered extrinsic when the incentives are economic or social.

What motivates people to perform best at their work? Job satisfaction seems determined by the origin of the incentives. Those who respond to an external incentive view their work as a "job," necessary to make money but not otherwise fulfilling, and are the least satisfied. Those who view work as a "career"—that is, an opportunity to advance and grow personally—are more satisfied. Those who view work as a "calling" report the highest level of satisfaction with their work and their lives.[5] Some research suggests that for an intrinsically motivating task, intrinsic rewards are more effective. People's interest survives best when rewards are used neither to bribe nor to control, but to signal when a job has been well done. Rightly administered, intrinsic rewards can stimulate high performance and creativity.[6] For example, it is possible to link performance of a task people do not want to do with something that they want.[7]

Efforts have been made to motivate people through extrinsic incentives under the economics-based hypothesis that people want to earn more money.[8] However, such motives may not function as hypothesized, partly because people make decisions by using behavioral rather than classical

Box 14.1. Extrinsic Teacher Incentives and "Cramming" for Exams

Advocates of paying teachers based on student performance argue that they can strengthen weak incentives, while opponents argue they promote teaching to the test. In a randomized experiment in Kenya, where absenteeism is 20 percent, primary school teachers in rural Kenya were given incentives based on students' test scores. During the time the program was in place, students in program schools had significantly higher test scores in at least some exams.

An examination of the channels through which this effect took place, though, provided little evidence that teachers worked harder. Teacher attendance did not improve, homework assignments did not increase, and pedagogy did not change. However, teachers tried to raise test scores by conducting more test preparation sessions. While students in treatment schools scored higher than their counterparts in comparison schools during the life of the program, they did not retain these gains after the end of the program.

Source: Glewwe et al. 2003.

economics. For example, they may discount distant benefits, such as the promise of pensions, in light of short-term losses. A meta-analysis of 39 studies in the United States showed that financial incentives did not lead to improved performance *quality* but had moderate correlations with performance *quantity*.[9] Sometimes extrinsic reward does improve performance, especially when the individual is not performing the behavior at all.[10] The general finding among both humans (and monkeys) is that offering an extrinsic reward for an intrinsically motivating task reduces performance and persistence. In short, an intrinsically motivating occupation becomes like work.[11] Thus, financial incentives are often not effective in improving performance.

Worldwide teacher salaries are low and falling relative to the per capita gross domestic product (GDP),[12] particularly given the employment opportunities open to men. Psychological research on incentive types has rarely been carried out on very poorly paid personnel, and the influence of incentive mixes for such a population is unknown. One study found that teachers were less satisfied with salaries than with other aspects of their job and that satisfaction with salary had a strong and significant impact on school attendance. [13] Perhaps extrinsic incentives and a real possibility of losing a job due to poor performance might motivate teachers to perform better. For example, *contract or partly "volunteer" teachers* working for particularly low salaries might respond to extrinsic incentives. An analysis of test data from West Africa showed contract teacher status as having a strong positive correlation with student achievement, but a teacher absenteeism study[14] found that contract teachers had the same absenteeism rate as others.

Some countries have experimented with programs to link salaries at least partly with performance. For example, Israel, Bolivia, Chile and Mexico, have tried to improve teacher quality by establishing salary differentials or granting bonuses for teachers working in rural areas, or rewarding teachers' with exemplary student performance. In Israel student achievement increases have been noted[15], but elsewhere the results have been modest. Neither the Mexican nor the Bolivian program has shown effects on student performance, and the Chilean program has shown effects only in the more recent assessments. Problems have included a limited opportunity to participate and a small reward size, amounting to only 5 to 7 percent of the salary. In addition, the literature on the impact of teacher incentives has documented various adverse or unintended consequences that include increased cheating, forcing low-performing students to drop out, 'teaching to the test' to the detriment of other skills, providing out-of-school paid test tutorials, and even increasing students caloric intake on the day of exams.[16]

As predicted by psychological research, a mixture of extrinsic and intrinsic incentives may prove more effective. More secure employment contracts have been found to increase job satisfaction and indirectly reduce teacher absence, while others, such as teacher-recognition programs may have an independent effect on absence.[17] In remote rural areas, where teacher absenteeism may rise to 40 percent (Chapter 10), an innovative mix of extrinsic and intrinsic incentives was found to increase teacher attendance and student achievement. In the Rajasthan desert, an NGO successfully increased attendance from 58 to 78 percent by asking teachers to record their attendance on film. Teachers were given cameras and were asked to take photos of their class at the beginning and the end of class each day; on the basis of the dates shown in the photos, teachers were paid extra for attendance. A year after the start of the program, test scores in program schools were 0.17 standard deviations higher than in the comparison schools and children were 40 percent more likely to be admitted into regular schools.[18] The improvement was partly attributed to teachers' realization that the education authorities took an interest in their work.

Efforts to offer purely intrinsic incentives have also shown modest outcomes. Teacher recognition programs were shown to be ineffective in many countries, but they were found to reduce absenteeism in a few countries. In Indonesian with a teacher-recognition program for example, teachers were absent at rates 9 to 12 percentage points lower than other teachers. [19] *School grants* may function as intrinsic incentives for teachers (Box 14.2). These programs encourage teacher groups to apply for funds that fulfill certain school or training needs. They are very popular in many countries. They may benefit teachers by creating tighter linkages among them and ministry authorities, thereby creating a climate for addressing school problems and fostering planning and decision making. Teachers may arrive at novel solutions, spend more time in school, and feel proud of achievements. Regardless

Box 14.2. How Do Teachers Use School Grants?

In 1997, 25 schools in Kenya were selected to receive block grants that could be spent on several options, such as textbooks or other school supplies or construction of new classrooms. The purpose of this intervention was to see whether funds are used more effectively when schools are given a choice on how the money is spent. Analysis of results indicates a small but statistically significant impact on test scores after one year, as well as reduced dropout and repetition rates. The impact seems to diminish over time. As with other interventions involving educational materials, the better students seem to have benefited the most.

Source: Glewwe et al. 2001.

of eventual outcomes of school grants, the greatest benefits may be on teacher involvement and creation of linkages with others.

The challenge is to find an effective mix of intrinsic and extrinsic teacher incentives. Incentives programs demand logistics and staff to implement them – who may themselves not be very motivated to do the work. Given the importance of intrinsic incentives, teacher training could focus on the "bigger picture" and personal reinforcement that good teaching may give. Teachers could be asked to consider students' success, a good name for themselves in the community, and other culturally pertinent motivators. More research and field experimentation is needed to understand the incentive mixes that teachers will work for.

Self-Efficacy and the Challenge of Never-Ending Tasks

Self-efficacy refers to people's beliefs in their ability to carry out required actions and attain a specific goal.[20] The stronger one's perceived self-efficacy, the more one will exert effort and persist at a task.[21] For example, students' self-efficacy expectations (rather than actual ability) predict their willingness to consider various occupations. Evidence from diverse methodological and analytic strategies verifies that perceived self-efficacy and personal goals enhance motivation and performance attainments.[22] Research in 25 countries with over 19,000 participants[23] suggests that self-efficacy is indeed a global, cross-cultural phenomenon. In West Africa, for example, one study found that teacher satisfaction was positively related to student achievement, while salary levels were not.[24]

Self-efficacy and the perceived importance of a task determine whether people will be motivated to carry it out. Teachers who do not know some topics matter well may feel that they do not have the efficacy to teach them and avoid the situation (Chapter 15). Motivation may be low if exams are perceived to be impossible or if good performance is considered unimportant[25] (as may be the case with students taking low-stakes learning assessments). Most important, people may be less motivated to produce when goals are ambiguous, and they are unsure what to do. The mind seems prepared to take action when reasons are clear and goals have relatively short-term timeframes.[26] Teaching may be adversely affected by this tendency. Some may perceive it as a repetitive, never-ending task lacking milestones and real progress; even if all the objectives are achieved in a school year, new students come next year who will have to achieve them all over again. Furthermore, the time available to do the job may appear infinite to some teachers, because a school year seems long and most children will come back the next day. Inspectors and principals may also perceive their jobs in similar terms; supervising teachers is a never-ending task that may not often culminate in a real outcome.

The challenge is how to succeed in a task that seems inchoate. Organizational research suggests that endless tasks should be subdivided into more manageable chunks.[27] It is helpful if employees are led to state specific, incremental goals with subgoals and "implementation intentions" or action plans that specify when, where, and how they will march toward achieving those goals. Then they become more focused in their work, and on-time completion becomes more likely.[28] Thus, a goal that is distant in the future must be made more immediate, tangible strategies must be developed to get there, and indicators of success must be developed to keep performance high and prevent people from becoming discouraged. Frequent reinforcement is also needed to maintain motivation under such circumstances.[29] In Japan, for example, teachers spend a lot of time in teams thinking how to teach various concepts by developing "research lessons," a process that keeps them engaged on a short timeframe. *School improvement plans* (carried out, for example, in Brazil and Indonesia) may serve the desired purposes of micro-planning the achievement of difficult tasks. Spending time on such tasks, however, is possible mainly when teachers do not have second jobs and may not be feasible in countries where salaries are particularly low. For those who must teach in multiple schools, options are limited.

Increasing Accountability

Organizational research on *accountability* has relevance for educators. *To be truly accountable, individuals must first be solely responsible for an outcome, and not simply a cog in a larger mechanism.* In systems where there is redundancy, accountability is more limited; that is, if others can or will do the work and pick up the slack, then most employees may feel less accountable and perform less well.[30] (This is a concept similar to social loafing discussed in Chapter 13). Often low-level workers feel less accountable than managers, particularly if they are less involved in the outcome.[31] Hierarchical organizations with a clear chain of command, reporting, and reinforcement may be the most effective in identifying the employees who are accountable for certain work; but it is also possible to increase accountability through a focus on responsibility and individual agency rather than mere top-down control.[32]

Accountability has the same effects on a person as motivation; it increases alertness and attention. Employees held accountable think harder about the issues of their work than others who are not accountable.[33] Because judgment becomes important, people become involved and use more information, develop more complex strategies, and their accuracy may increase.[34] These findings may account for some management theories that emphasize implicit contracts and patron-client relationships among parties, which outsiders may not comprehend.

Many efforts have been made to hold teachers responsible for learning outcomes, but the many social variables affecting students make this linkage difficult. However, tight organizational and cultural linkages may foster accountability. Systematic evaluations and peer reviews are examples of such linkages, and this is one reason why evaluations can promote professionalism and performance.[35] These social forces can be used to make teachers think harder about their work and to increase their sense of meaning in it.[36] Regular teachers' meetings and peer-led inservice training may be effective in this respect. Empowering a principal to have some control over teachers' work is important, as shown through research on effective schools.[37] Frequency of supervision results in lower absenteeism and better student performance.[38] However, in many countries or regions, school-based management is still not implemented, and the principal's role is limited.[39] As a result, teachers and administrators are often not tightly linked. This is particularly the case when schools are remote and transport is hard to get. When teachers rarely receive visits from anyone, they may feel less accountable to the system, and may have inordinately high absenteeism rates.[40]

Teacher evaluation and supervision are often a relatively complex and bureaucratic procedure that is carried out infrequently. Supervisors and inspectors often have no direct responsibility for the good operation of schools or for student performance, so they may have few incentives to carry out repetitive routines. However, principals can simply supervise instruction by walking regularly into a classroom and observing instruction for three minutes. In a *three-minute classroom walk through* a principal may consider (a) whether the objective taught at that moment is appropriate for that particular grade level and (b) whether the instructional techniques used are likely to teach the objective to the students. Then the principal may give five minutes of feedback to teachers, helping them reflect on these two issues and reconsider the decisions they make.[41] School administrators could be trained to use this rather simple technique to increase overall instructional time and time spent on interactive instruction while decreasing time spent off-task or less productive seatwork (Chapter 8). With the low cost of technology and worldwide telecommunictions coverage, teachers in remote areas might be supervised through cell phones and other suitable media.

One means to increase performance has been the policy of holding teachers accountable to communities. Some countries, such as El Salvador, Guatemala, Honduras, and Nicaragua have devolved authority to communities, granting professional autonomy to schools and teachers in the belief that the increased accountability will lead to higher teacher quality and student outcomes. Chile is also attempting to eliminate job stability for poor-performing teachers. Outcomes are mixed; student performance showed improvements in Honduras and El Salvador, but not in Nicaragua.[42]

Communities in Central America often monitor schools effectively, but in other parts of the world, the existence of parent-teacher associations is not linked to improved achievement or even increased teacher attendance.[43] Many of these often male-dominated associations are set up externally and may not include members that are very much interested or willing to undertake the considerable involvement that is required. Thus, there may not be much "social capital" in the group to be devoted to educational purposes. However, communities might be trained to observe classroom events and monitor simple benchmarks, such as listening to children read and determining whether they can read fluently in grades 1–2.

Teachers may feel more accountable to communities if they are members of the same in-group rather than outsiders who are less highly regarded (Chapter 12). Some donors and governments have promoted the strategy of hiring local persons, mainly female, and training them (a strategy implemented through UNICEF in mountainous Yemen for a decade). There are also risks in hiring staff who may be hard to replace or help improve if they do not perform when they are influential members of the community. But no evaluations have been found of this strategy and its tradeoffs.

Policy Implications

Countries interested in offering incentives to reduce teacher absenteeism and improve performance of low-income students must carefully weigh the mix of intrinsic and extrinsic objectives, pilot various combinations, and carefully consider the research evidence.

Psychological research underscores some of the reasons why principals and supervisors (or inspectors) must have regular meetings with teachers that include discussion of short-term goals and feedback. A functional supervision chain is needed that extends all the way up to regional or central governments. Its linkages can be reinforced with social events and professional evaluations. The supervision function is not necessarily complex. Administrators and supervisors may watch teacher performance on a short list of variables and provide frequent and supportive feedback. This would include monitoring of teacher absenteeism and tardiness.

Modalities in making communities effective supervisors of schools must be tried out more extensively. Simple standards might be given to communities to help them know when teachers do a good job. One standard that is feasible is the goal of making all children read well by the end of grade 2. The communities could hold reading contests and reward the teachers who achieve the goals. Rewards might also be given to NGOs that manage to make students literate in 4–6 months as research has shown is possible.

15
Performance and Training of Educators

> ***Learning Essentials***
>
> The principles that influence retention of material in primary schools also hold for adult training. Donors and governments who pay for training of teachers or other staff may get the expected benefit only if the content is recalled when needed and behaviors are suitably modified. One-time sessions, far from the workplace, in large groups, and with people who do not see a clear need for the information are likely to be forgotten. At best trainees may recognize the concepts presented but not change behaviors.
>
> The donor community has made large investments in preservice and inservice teacher training, but decisions about content and methods are usually left up to local staff, who may not have sufficient expertise. Thus, training often fails to make instruction more effective or serve the students' best interests. Training in applied learning principles, basic math, and counseling on social issues related to students might help improve learning outcomes.

Perhaps teachers' willingness to carry out Education for All has been taken for granted. The initiative has opened up a large job market in some countries, but the demand is for people willing to work for low salaries that remain compressed for years. The salary structure favors those who are less educated, less experienced, and female.[1] Yet, teachers are expected to teach effectively, treat children well, and be motivated enough to perform consistently even if rarely supervised. Predictably, the market may not attract the highest caliber of candidates, either in academic or in ethical terms. This section discusses some issues raised in educational studies of teacher performance and training.

Social Status and Attitudes toward Students

Teachers and supervisors are not immune to racism, sexism, and social exclusion. They may have different expectations from particular ethnicities and genders.[2] They may feel ambivalence about educating poor or low-caste children who may then expect higher wages. Others may resent students who are financially better off and who may attain higher educational levels than they. Teachers may have mixed feelings about the social status of teaching, particularly in poor or rural areas, and the status of the families they deal with; university trained teachers in particular may feel that the job is beneath them. Most important, teachers may have learned from their own student years that only a few students can meet standards. They may be teaching not to all but to the select few and expect the other ones to drop out.[3] Some inspectors and supervisors may in turn have similar feelings towards students and teachers.

Schools in low-income areas may not always be "child-friendly." With increased demand for education, reported instances of bribery have increased,[4] as have anecdotes of students mistreated physically and sexually.[5] Teachers have been known to sell front-row seats, charge parents to correct homework, and require private tutoring fees to ensure that students pass to the next grade.[6] Sadly, trade union membership has been sometimes linked with rent-seeking behavior, reduced time for students, and low student achievement.[7] Some countries tolerate nepotism and bribes in teacher appointment and examinations[8] as well as "ghost teachers" who get paid without teaching. They may also have policies of "unfavorable transfers" of problem teachers to low-income schools. A study in Peru[9] documented a startling lack of interest by some teachers in children's learning.

Attitudes toward Teaching

Even teachers who have good intentions may be thwarted by the problems of poor classrooms, as described below.

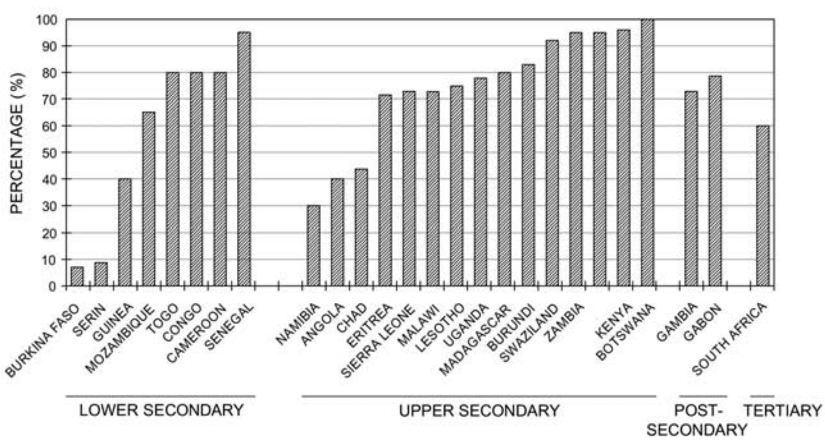
Discouraging response of poor students. In the classes of better-off students, the teacher presents material and expects most students to master it, albeit with family help. In the classes of the poor there is no outside help, so it becomes the teacher's responsibility to present the material again and again and think hard how to do it. The work is much harder, and children with cognitive delays and limited attention spans may be harder to teach. Even the best teachers cannot overcome the effects of anemia and long-term malnutrition. On the other hand, poor students may be passive and appear well behaved, so teachers may not have classroom management problems.

Need to prepare for class. Effective teaching and feedback involve preparation of lesson plans and grading of homework. This is often a tedious task that may also interfere with a second job. To minimize work after hours, teachers may assign students less-productive seatwork (Chapter 8) in order to catch up with grading, or they may simply dismiss classes early.[10]

Limitations of teachers' academic knowledge. In many low-income countries, teachers do not meet even the minimum qualifications and many have not fully mastered the curriculum (Figure 15.1).[11] Studies show that effective teachers have more content knowledge.[12] Tests given to some African teachers suggested that they did not know much more than the students,[13] particularly with respect to math. Teaching math requires an ability to do complex mental calculations fast in order to check students' answers. Teaching all subjects requires the ability to formulate questions, think of reasons for various effects, challenge students, and think faster than they do. The demands on long- and short-term memory may be excessive if knowledge is limited, and teaching may become stressful. Glucose may be depleted in the teachers' brains during the course of demanding exchanges with students and arouse feelings of mental fatigue.

Teachers who have limited knowledge may feel uncomfortable when students ask them questions, particularly if students progress to the point of asking difficult questions. This may be one reason why some teachers prefer "teacher-centered" teaching that goes through a routine and minimizes such interactions. They may also face other task-related stressors. Instruction of never-ending cohorts of primary students in the same basic skills and correction of the same spelling mistakes while disciplining

Figure 15.1. Percentage of Primary-School Teachers Meeting National Qualification Standards in Sub-Saharan Africa, 2001



Source: EFA Global Monitoring Report 2004, p. 109.

students may be tiring to many. The endless task of teaching combined with the boredom caused by the constant lecturing that is the norm in many countries may be reasons for the widespread *teaching avoidance* documented in instructional time studies. Not only are teachers absent 25 to 30 percent of the time and frequently late, they are also about 50 percent likely not to be engaged in teaching when they are in school. They may be sitting under a tree or talking to colleagues and students.[14] Teachers from societies that place less emphasis on time may not realize the cost of time in terms of government spending and children's lives.

The reward limitations inherent in the teaching profession coupled with the stressors of managing tasks and children may lead to teacher burnout.[15] These may be some of the reasons why teacher effectiveness tends to peak at 22 years of training and decline thereafter.[16]

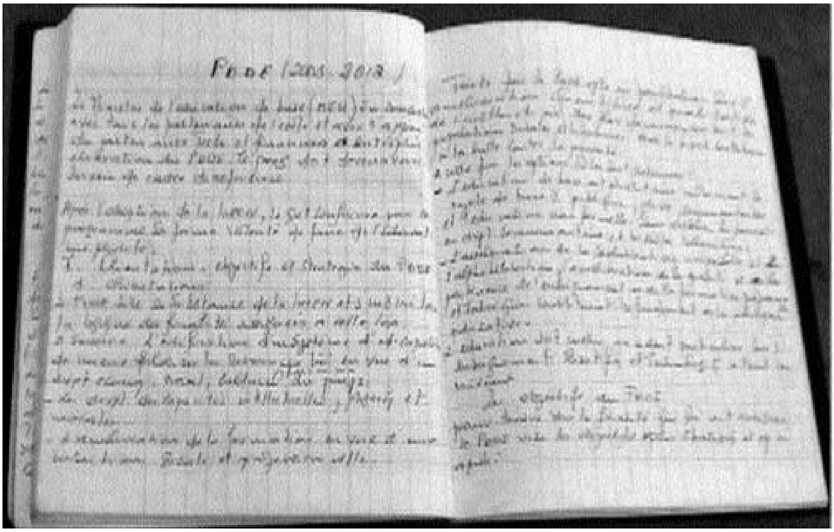
Teacher Training Institutions May Not Teach Effectively

Observations by IEG missions suggest that instructional activities in many teacher training institutions mirror the activities of primary and secondary schools. Student teachers spend their time listening to lectures and reciting sentences on topics such as teaching theories, evaluation, community linkages, sociology, or psychology. They may also complete group projects and review their skimpy notes, since they typically lack textbooks. In Guinea and Niger, where student teachers have very limited knowledge, instructors may dictate the texts verbatim—an activity similar to copying from the blackboard in primary schools (Figure 15.2). Practice teaching in many countries offers limited supervision, and supervisors may not know themselves how to teach effectively.

In some respects, however, there is no such thing as an untrained teacher. Students extract teaching rules from the past behavior of their own teachers (Annex I-C, II-B). These may include absenteeism, inefficient use of time, rote memorization, mistreatment of students, infrequent use of textbooks, and expectations of low performance. The mental statistics calculated by witnessing countless similar events may not be readily modifiable through lectures or textbook advice. New teachers are particularly likely to perform according to their prior experiences[17] and to adopt counterproductive practices that are used around them in the school.[18] Previous experiences also influence beliefs that are reportedly difficult to change during preservice education.[19]

One reason for this phenomenon is that people are genetically programmed to imitate, particularly during childhood. Mirror neurons fire when others make various movements and make it possible to understand people's intentions.[20] Much social information is transmitted by such observational learning, and it becomes a part of implicit memory

Figure 15.2. Notes Dictated During Class in a Teacher Training Institute of Niger



Source: Author.

(Chapter 4). People are more likely to imitate behaviors that they can realistically carry out and that can earn them rewards. Thus, people imitate those whom they regard as successful or those whom they would like to resemble.[21] People even model behaviors that were unpleasant to them; in parenting, for example, people tend to treat their own children as they themselves were treated, even if they disliked it, or were "taught" differently.[22] This is why mere provision of teacher training information is not sufficient to change behaviors.

Improving the Effectiveness of Teaching Behaviors

We know more about what does *not* work in teacher training than what works. Several countries (such as Dominican Republic and Honduras) have implemented extensive and often degree-oriented teacher training programs aimed at making teachers more competent to perform in class. Yet, such training often does not improve student test scores.[23] One reason may be the tendency of degree-oriented courses to focus on high-level analyses of various educational issues rather than the content of primary-school subjects, such as fifth-grade arithmetic. Thus, basic deficiencies in teachers' knowledge that influence what children learn may remain unremediated.

Teacher performance may benefit more from a practical, vocational-education focus on how to cover the curriculum. For preservice training it may be beneficial to develop a succinct curriculum of learning fundamentals that teachers are likely to find useful in school, such as implications of reading and math automaticity, how cognitive networks encode information (Annex II-B), the consequences of various learning activities, how to optimize time on task, effective grouping activities, effective classroom management techniques, treating students well, and rewarding them. Teachers must also learn how to explain cogently the underlying rationale of the procedures or information taught and how to ask students questions that connect information items and develop deductive reasoning. They might also receive feedback about the effects that specific classroom activities have on the learning of their own students and be prompted to present material so that all will learn. These topics could be produced in brief texts and videos for dissemination. (See next section.)

The social and cognitive peculiarities of teaching and supervision are rarely addressed explicitly. *Group discussion sessions* during inservice and preservice training might help teachers, supervisors, and trainers of trainers examine their beliefs, clarify feelings about teaching, challenge preconceived biases, and put new conceptions into practice.[24] Discussions should deal with issues that teachers may have witnessed in childhood and therefore consider "normal," such as time wastage, large-scale failure of students, harsh punishments, or sexual harassment. Teachers might be directed to reflect on their perceptions of normality and then improve performance to a level above "normal." Arguments and techniques could be developed to help them change behavior and get intrinsic satisfaction from interaction with children who will later remember them kindly (Chapter 14). T-shirts emphasizing group pride might be used.

To implement effective teaching methods, educators must experience new role models and become convinced of their rationale and utility. Champions are needed who are respected educators, have "emotional intelligence," and are able to resolve conflicts and convince others to carry out what must be done. Little research has been undertaken specifically on teachers' likelihood to model certain behaviors, and much more is needed.

Improving the Effectiveness of Training Events

The completion reports of World Bank projects often present the numbers of people who receive training through a project. The numbers are often large and impressive: "3,000 teachers and 1,500 administrators were trained" or "all teachers in the country are now trained." Training outcomes and details are rarely reported. How well does training work and what could be done to increase its efficiency for educators who are frequently middle-aged?

Institutional development depends on training that is remembered and put to use. The most frequent vehicle is workshops consisting of lectures, instructions, and delivery of reading materials. Inservice training often consists of occasional one-time affairs directed in general to large numbers of staff. People who seek the information are more likely to retain it even if they receive it through a dry presentation. But obligatory inservice training means that learners may not have a clear idea of the utility of the information. To learn, they must be engaged through activities that promote recall and maintain their attention. (See Chapter 8 and Annex II-B and II-L).

One obstacle to behavior change is that *training given outside the workplace may not always be recalled during work.* Recall depends on the environment where material has been learned, so the suggestions offered while in a seminar may not transfer into classroom situations (See state-dependent learning in Annex II-B). This may be more problematic if training sessions include lecturing to large numbers of staff who may remain passive. Trainees may have limited opportunities to contemplate the messages and may also be subject to "social loafing" effects, particularly if there are few incentives for learning the training material (Chapter 14).

One-time large training sessions are often inevitable because they may be cheaper and easier to plan. To maintain staff attention in one-time training sessions, the "memorability" volume should be turned up. Information will be more likely to be remembered and put to use if training is conducted through *multimedia* presentations, including demonstration videos from local schools to illustrate various positive and negative practices. The number of messages must be limited (some say to a maximum of three) and these might best be conveyed through funny, unusual, and emotional events, as well as through visual imagery. Storytelling, analogies, and similies easily embed new information into existing cognitive networks. Learners could be invited to visualize and contemplate their own practice along with needed changes (Annex II-M). Feedback for error correction might be provided by colleagues. Discussion groups of about five people might be constituted to discuss how and when they will use the information. If possible, there should be requirements for review before sleep, good use of workshop time, and a final examination (that demands individual analysis rather than just group projects). It may be useful to link completion of training requirements to incentives such as promotions. Training courses could also involve follow-up by the principal and supervisors. If training says one thing, but the administration makes teachers do another, change will not take place.

The low cost of technology makes it possible to transport computers and give multimedia presentations in poorer areas. Well-articulated, computerized, multimedia materials for teachers are also needed to role-model desirable behaviors in memorable ways. Scripted materials may also be developed to deal with teacher weaknesses in areas like language (Chapter 9). Such training courses are challenging and may require more time and resources than systems have available. However, it is worth using cognitive research to make training memorable. Learners often have to repeat the important messages to teachers through *cascade training*. Supervisors may visit schools to provide such training or meet groups of teachers at predetermined sites and intervals (*cluster training).*[25] The challenge is how to build a chain of trainers transmitting the correct messages from a central department down to the teachers. Both the integrity and the memorability of information are important.

State-dependent learning is a problem also during *study tours*. Many donor projects include visits and training abroad in hopes of exposing officials to different procedures that might be useful in a country. Since training abroad involves trips, it is coveted (and, unfortunately, high-level officials may go, rather than staff who could actually use the information). The information received during study tours may be more memorable because it will be probably coded distinctly from routine events and may thus be more retrievable. Staff are likely to remember what they saw and describe it. On the other hand, state-dependent learning predicts that the information may not often be brought to mind when faced with a situation where it is needed. And since middle-aged people may not encode material as durably (Annex II-L) the information may only be vaguely remembered as a pleasant episode of a journey. As with other types of training, elaboration and connection with the situations in the country and the office are needed. The agencies financing study tours might structure time and opportunities to discuss lessons learned after the staff return to their jobs.

Policy Implications

The donor community has had relatively limited involvement with the content of teacher training curricula. With a better understanding of the origin and modifiability of teacher behaviors, specific policies can be put in place regarding what should be taught and how. There is sufficient information to formulate a research-based curricular framework and train trainers in it. It could be piloted for effectiveness in making students literate and numerate sooner than the usual timeframe.

In Africa, a central training facility might be developed through organizations such as the Association for the Development of Education in Africa (ADEA) or the UNESCO Teacher Training Initiative for Sub-Saharan Africa. The challenge would be to find champions and leaders able to convince others to adopt research-based teaching strategies and disseminate them in training events through techniques that maximize the probability of behavior change (Chapter 15, Annex II-L).

Donor and government staff responsible for execution or disbursements on various training events might emphasize the need for training that will be retained and put to use. These leaders should budget accordingly, commission multimedia presentations, avoid one-time passive lecturing events, and request feedback from learners after they return to work on the viability of the messages they received. Field trials might be needed to assess the benefits and costs of such training events.

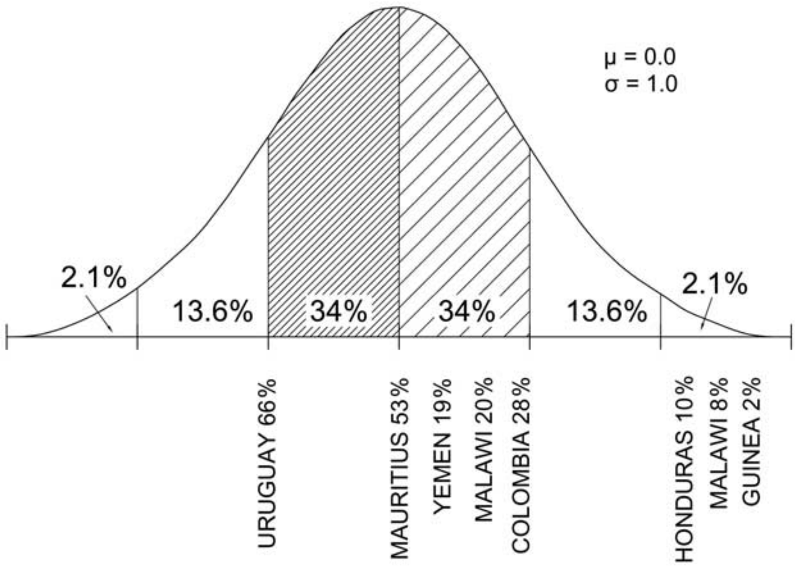
16
The Seven Pillars of Basic Skills for All

Never before in history have so many children on earth gotten the chance to master basic skills. How many can realistically do so? Achievement tests in various countries make it possible to arrive at some rough estimates.

Psychometricians hypothesize that cognitive ability is normally distributed.[1] The percentage of children who can learn basic skills through various interventions (considered here as "ability") can be roughly expressed as areas under a normal curve whose mean is 0 and standard deviation is 1.[2] The learning assessments of various countries usually publish the percentage of students who met certain criteria for "minimal" or "acceptable" achievement levels (usually 60–75 percent of items answered correctly). Though not directly comparable with each other, test scores of grades 5–6 illustrate the gap between expectations and achievement in each country.

Education "for all" might be construed as aiming to reach about 97.9 percent of the students—those with "ability" down to –2 standard deviations—or perhaps just 84.3 percent, those with "ability" down to –1 standard deviation in each country. (Some may be too handicapped to benefit). Test scores suggest that the percentages of students effectively educated are very small compared to the EFA expectations. Even in middle-income countries like Uruguay and Mauritius only about two-thirds of the students score acceptably (Figure 16.1). In rough terms, these countries serve satisfactorily students whose ability to perform (given social limitations) places them at –1 standard deviation on the normal curve and probably offer at least basic literacy even the to 15.9 percent of the students placed –1 and –2 standard deviations. However, in countries like Guinea and Malawi mainly the few exceptional students with "ability" at +3 standard deviations can perform satisfactorily. It is unclear how many others acquire basic literacy. What resources and strategies will be required to enable countries like Guinea to impart basic skills not just to 3 percent but to 84.3 percent of its children?

Figure 16.1. Relatively Few Students Meet Mastery Criteria in Various Countries



Sources: Guinea—Barrier et al. 1998; Honduras—Honduras. Secretaría de la Educación 2002; Uruguay – ANEP 2003; Yemen – ERDC 2000; others, Table 1.1.
Note: Distributions of tests mentioned are usually skewed toward lower scores, so hypothesized ability levels may be overestimated.

Research presented in this document suggests that countries can teach most of those who currently drop below literacy or remain illiterate by changing a few crucial policies. It is possible to reduce the very complex educational picture to a finite number of manageable policies and activities with monitorable outcomes that have the biggest impact. (These also pertain to the EFA goals 1, 3, and 6, shown in Box 1.1). The most important seem to be the following:

1. Support children's brain development for efficient learning *(Chapter 2).*
2. Use every moment of the available instructional time *(Chapter 10).*
3. Ensure that all have textbooks to take home *(Chapter 11).*
4. Learn fluent reading and calculation in grades 1–2 *(Chapter 5).*
5. Teach basic skills to young students in their mother tongue *(Chapter 6).*
6. Base educator training on a few well-researched learning principles *(Chapter 15).*
7. Ensure effective teacher incentives, goals, and oversight *(Chapter 14).*

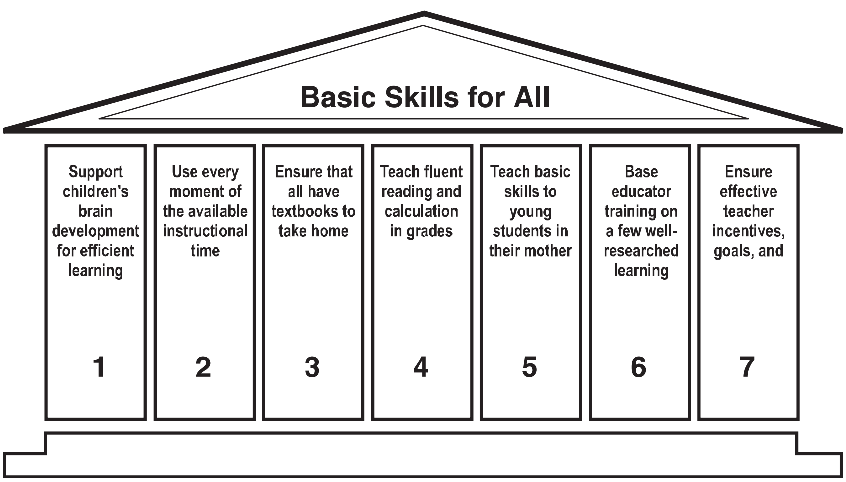
These issues (summarized in the Overview) broadly agree with the recommendations of studies linking achievement tests to various school inputs of low-income countries. A 2001 study of PASEC scores in five Francophone African countries found that the largest determinants of quality were textbook availability, local-language instruction, larger classes rather than split shifts, use of female teachers, low absenteeism, teacher job satisfaction, visits by an inspector, and contract teacher status.[3] Thus, policy actions might be centered around a few systemically significant variables, including judicious interventions in classroom instruction (Tables 16.1 and A-2).

Benchmarks and Monitoring Indicators

Several of the concepts discussed in this document result in quantitative monitoring indicators, for which data can be collected at the local level.

Instructional time. The time students spend engaged in learning is the overarching issue that almost encompasses every other. An empirical snapshot can be made on what the class was doing when a supervisor or principal walked in. Teacher absenteeism and school closures can be ascertained through school surveys directed at the principal, teachers, and students about recent absences and obtaining data from school records when they are available and reliable. Together these data help estimate the percentage of instructional time used to engage students in learning. (The World

Figure 16.2. The Seven Pillars of Basic Skills for All



Source: Author.

Bank has piloted surveys and estimates through a grant from the government of the Netherlands.) Governments can carry out instructional time surveys to monitor changes, provide feedback to schools, and inform the public on the use of tax monies.

The EFA indicative framework includes 850 hours of instruction but currently does not specify goals on their use (Box 16.1). More specific targets are needed. For example, schools should actually operate 90 percent of the stated number of days, on average; 90 percent of the teachers should be in school on a given day; and the time engaged in learning in classes should increase to 75 percent (excluding extensive copying due to a lack

Box 16.1. An "Indicative Framework" for Educational Quality in EFA Countries

The following access indicators are included in the framework:

- government spending on education—20 percent of budget
- spending on primary education—50 percent of education budget
- teacher salary—about 3.5 times GDP per capita
- pupil-teacher ratio—about 40:1
- nonteacher salary spending—33 percent of recurrent spending
- average repetition rate—10 percent or lower
- annual hours of instruction—850 or more
- unit construction costs—US$10,000 or lower

The following quality-related indicators might be added:

- *Instructional time use:* Schools should be open at least 90 percent of official days, teachers present 90 percent of open days, and classes engaged in learning at least 75 percent of the time.
- *Early mastery of fluent reading:* By the end of grade 1, nearly all students will be able to decode; by the end of grade 2, 95 percent of students will read at 45–60 words per minute with 90 percent accuracy.[a]
- *School health:* All students should be free of parasitic infections and deficiencies of iron and iodine that significantly reduce cognitive processing. (School feeding is highly desirable if it can be reliably organized at reasonable cost.) Country-level school health targets should be set based on local prevalence in collaboration with the health sector.

Source: Author.

a. Early mastery of arithmetic is equally important, but math tends to correlate highly with reading (for example, 0.73 in Uruguay; ANEP 1998, p. 50).

of textbooks). Actions to improve use of instructional time might be a requirement for receiving funds for EFA activities.

Literacy Acquisition in Grades 1–2. Fluent reading by the end of grade 2 is a clear benchmark that is furthermore comprehensible and monitorable not just by specialists but by community members as well. The percentage of students in a sample who can read fluently can be ascertained through a brief oral reading test.

Health indicators. Extensive data are collected through health surveys that can be used for monitoring health improvements. Closer linkages with ministries of health can help obtain school-level data.

Invest More in the Lower Grades: Prospects for a Policy Shift

How much learning does a year of education budget support buy? In many countries it buys little. One reason is failure to learn reading, which *creates inefficiencies that reverberate all through the system* to the university years. The failure translates into dropouts, grade repetition, and a need for extra teacher salaries, classrooms, and materials. Accumulating deficiencies may also be responsible for the widespread cheating on the exams as well systemic corruption.

Providing education to the poorest may have a higher marginal cost than educating the middle class. But there is also an inverse relationship between grade level and expenditures: the lowest grades get the fewest resources. Governments and the donor community should be prepared to spend extra for reading programs after hours or during vacations with books students can take home. Rather than receive fewer hours of instruction, the early primary grades should receive more, particularly when a second language must be learned.

Estimating incremental costs for recommended quality interventions is beyond the scope of this publication. However, many interventions have relatively low costs and would increase the effectiveness of bills that are already paid. Increasing instructional time use implies incremental costs in supervision and training, including multimedia training materials that are more memorable. Improving students' reading performance requires possibly doubling the textbook expenditures, but these are usually very low. Materials and related expenses only amount to about 25 percent of recurrent expenditures, and textbooks cost about US$2 each; the textbook bills could easily double. In countries of multiple languages, the donor community might pledge to finance the printing of mother-tongue instructional materials, which are also often less likely to be stolen. Such measures might raise expenditures in the short term, but there are likely to be long-term savings in terms of lower grade repetition and dropout.[4]

Efficient Access Goal: Maximizing the Numbers of *Literate* School Leavers

People cannot learn from sitting inside a class any more than people get cured by sitting inside a hospital. Enrollment and completion are not reliable or consistent predictors of learning outcomes.[5] For example, Niger had 25 percent enrollment in 1985, and probably most students became literate because they were from better-off families. By 2005, Niger boasted an enrollment of 46 percent, but the completion rate was only about 38 percent, and a 2000 survey revealed that only about 53 percent of grade 6 graduates reported that they could read well.[6] After US$100 million of Bank investments in primary education, the system may be producing about as many literate people every year as it did in 1985 (Box 16.2). Under such conditions, the unit price of one more student actually becoming literate may be astronomical.

A more reliable measure of progress than enrollment may be the net number of students made literate over time (either fluent reading by the end of grade 2 or basic skills acquired by the terminal grade.) However, the relationship between enrollments and number of students made functionally literate apparently is not linear. An econometric model is needed of how many students would acquire basic skills in 2, 4, or 6 years, given increased enrollments, actual instructional time, and opportunities to practice reading. The model would also calculate *the net number of students made literate through school* and the expense to make one more student literate, given the number of students graduating or dropping out illiterate each year.

At the current state of teaching, Education for All is impossible by 2015,[7] and the projections of many countries for EFA achievement by 2015 are not realistic (for example, Yemen). However, this initiative is achievable if it is redefined as functional literacy and numeracy for all. Children in relatively efficient schools get the greatest neuropsychological benefits during the first three years of school.[8] Increasing instructional efficiency and spending on the lower grades may make it possible to teach the very basic skills in 3–4 years.

Disseminating Lessons Derived from Cognitive and Neuroscientific Research

How can the lessons drawn from this research reach the classrooms of low-income countries in two or three years rather than a decade? Who needs to be convinced, which organizations can champion this agenda, at what level, and how could the task be organized?

Donor community members are in some way "wholesalers" of technical knowledge. To be integrated in the sector, the knowledge must be "retailed" in each country and fleshed out in greater detail and in accordance with national circumstances. A dissemination plan would address the knowledge needs and sensitivities of staff working in the education sector. Guidance must be specific but also general enough to respect the traditions and methodologies many teachers have developed after years of experience. Training in the new concepts could be offered through the World Bank Institute, UNESCO workshops, and various media. A simple teaching curriculum focusing on research-based methods must be developed for dissemination in various countries by champions—that is, staff with a particular interest in neurocognitive issues. If all the strength of UNESCO and the EFA mechanisms were spent on informing countries of the importance of early reading fluency, the children dropping out early worldwide would at least leave with one basic skill.

One obstacle to dissemination is that few people are familiar with this research, and they tend to be academics in industrialized countries. An additional issue to address is the limited donor involvement in instructional areas. The donor community has increasingly moved towards budget support to countries and away from project-based lending. The expectation is that donor staff will be less involved in day-to-day project details and should mainly carry out policy dialogue on sectoral and poverty issues. However, budget support does not mean that the donors should move away from technical advice and supervision; countries are often willing to accept technical advice, even if it is not tied to lending conditionalities. Thus, it may be useful for development agencies to hire professionals who know more about contemporary learning research and its implications on instruction. Recent graduates are likely to be more knowledgeable.[9] Because these issues disproportionately affect lower-income countries and lower levels of education, such specialists might be assigned to work in these countries while economists and generalists might work with countries where instructional issues are not as serious.

Research needs. Much of the research cited in this publication has been done in industrialized countries and may not always answer the questions posed by development agencies. Essential research is still needed on issues such as reading, language of instruction, grouping, and teacher motivation. (See relevant paragraphs in the preceding chapters.) It is also wise to convert the policy recommendations of this document into hypotheses to be tested experimentally. But research may take years to execute and the need must be balanced against the urgency to act. Policy options that carry a fairly high degree of confidence (Table 16.1) could be applied and evaluated.

Time is of the essence. The world is moving inexorably towards 2015. The Education for All goal can only be met if the "black box" of instruction is opened for good and the findings of neurocognitive research are inserted into it.

Table 16.1. Viability of Instructional Interventions for the Disadvantaged

Interventions with cross-national evidence	*Researched in industrialized countries, need to pilot in low-income schools*	*Limited research, but worth piloting and evaluating*	*Not suitable for the poor without extra time and help*
Phonics for reading (analytical-synthetic method)	Structured vocabulary building in mother tongue	"Direct instruction" (scripted basic skills teaching)	Immersion in a foreign language for basic skills
Maximal class time on interactive learning activities	Structured, directive teaching for lower-achieving students	Basic math in one language throughout school	Reliance on discovery learning to teach basic skills
Bilingual education, gradual withdrawal of mother tongue	Mother tongue development in preschool	Rightstart program for math competence	"Whole-word" reading instruction
Package of school health interventions, appropriate for each country	Teacher training based on role modeling issues	Sustainable grouping techniques for large classes	Learners constructing own textbooks, relying on materials from environment
Attractive schools with quiet classrooms with plenty of light and controlled temperature	Intrinsic incentives for improved teacher performance	Chewing gum when concentrated study is required	Split-shift with reduced teaching time
	Feedback to teachers on instructional time use	Music training and group performances	Teacher training focused towards advanced degrees

Source: Author.

Box 16.2. How Well Do Schools in Niger Improve the Country's Human Capital?

The World Bank has leveraged much of Niger's education budget for the past 20 years through investment projects and cash transfers to help expand enrollments as much as possible. The policy framework focused on reducing unit costs and included hiring large numbers of untrained teachers, cutting instructional time by 40 percent in urban schools, increasing class size to 40–45 students, multigrade teaching, and partly automatic promotion. The framework also accounts for the fact that students are taught exclusively in French. Enrollments increased from about 25 percent in 1986 to 43 percent in 2003. The country has been declared "ready" for the Education for All Fast-Track initiative and an annual progress report declared that all major outcome targets were achieved at large cost savings.

IEG carried out a Project Performance Assessment Review (PPAR) in May-June 2004. In classes visited outside Niamey, **none of the sampled students were found to be functionally literate.** Usually only half the students enrolled in any class were present. Teachers typically estimated that 30–50 percent knew how to read. But even the sixth graders graduating in 3 weeks read haltingly and did not know enough French to understand the texts or answer content questions. In the 1999 Monitoring Learning Achievement (MLA) test, 25 percent of fourth graders reached a minimum standard and only 2 percent reached a desirable standard. Household survey data showed similar results.

Explanations regarding the outcomes have differed. Economic explanations focused on the existence of "volunteer" teachers, teachers' strikes, lack of teacher motivation, irrelevance of the curricula to students' rural lives, lack of textbooks, and high absenteeism rates. Educational interpretations focused on the children's passivity, monotonous class activities, and unengaged teaching and classroom climate. All these factors are important, but the immediate problem was that children were not taught much. The few textbooks available were written for native French speakers. First graders were expected to know advanced vocabulary, and there were no glossaries in any language. Furthermore, children were asked to read one by one, and there was practically no time for all to practice. Not surprisingly, students had hardly any opportunity to learn.

Source: OED 2005a.

Annex: Cognitive Neuroscience Basics for Education

The annex presents the research that helps form a line of reasoning for the conclusions presented in this publication. Cognitive psychology (or cognitive science) is based on a long experimental tradition aimed at discovering how people think under various circumstances and has important educational applications.[1] Neuropsychology demonstrates how the nervous system creates the effects studied by cognitive psychology and seeks solutions for learning difficulties.

I. Neuropsychology Essentials

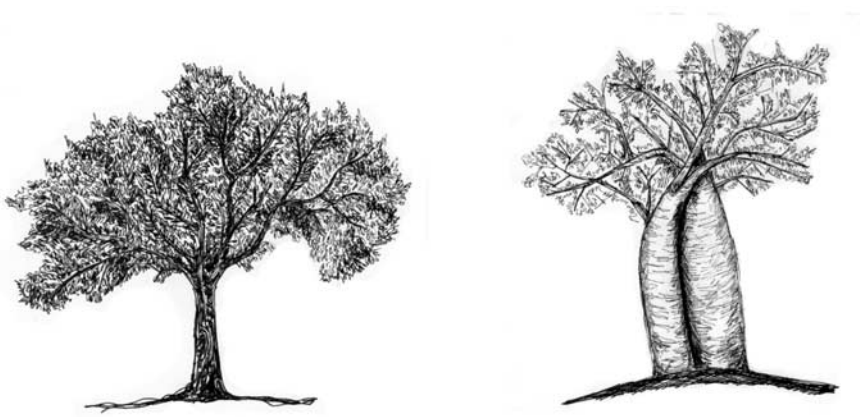
A. Neural Development in Young Organisms

The rules that determine which skills young people are likely to acquire are etched into neuron functions and interactions. During the period of the highest prenatal brain development (10–26 weeks after conception), it is estimated that the brain grows at a rate of 250,000 neurons per minute. At birth the brain contains the majority of the cells (neurons) it will ever have, about 10 to 20 billion. Thus, neurons are already well organized by birth and many have specialized functions. The brain of a young animal possesses an initial template of circuitry representing a "best-guess" of what experiences the animal will encounter. If the animal encounters the experiences normal for its species, this template is preserved and enhanced. But if the animal encounters something different during a critical period soon after birth, the connections can be altered to some extent.[2]

Young brains are made up largely of undifferentiated nerve cells (called "gray matter") that become specialized and make many connections during childhood. Thus children can become quickly adept at skills needed in their environment, such as sensing patterns in sea waves or discriminating the pitch of tonal languages. Experiences determine which skills will be kept and reinforced. The rest are discarded in "pruning" events[3] that happen periodically from preschool to late adolescence. Pruning events are a subject of considerable research. They probably account for the phenomenon of "critical periods" during which the brain can easily master certain skills, such as languages. Nerve networks may be lost just as schools expect students to learn certain competencies, and mastery may become more laborious. A better understanding of this phenomenon is likely to have curricular implications.

Gray matter gradually gets substituted by "white matter," which becomes increasingly more common and thicker from adolescence to about age 40. This is a sheath of fat (called myelin) that wraps neurons and helps speed up the transmission of electrical impulses. However, it also limits the new connections that can be made. Although new neurons are produced in the adult brain, they cannot expand into large new networks as in childhood. By the time of adulthood, the range of possible changes is limited: nerve trunks remain stable and only twigs and individual synapses change (Figure A-1). Brains become essentially an entangled mesh of neuronal connections, with axons and dendrites stuck together as neighbors for life.[4]

Figure A-1. Brain Potential of Younger and Older People



A young tree has many branches but a thin trunk

An older tree has a thick and efficiently transmitting trunk, but fewer possible new branches to develop.

Source: Author.

The human brain seems to mature from the back of the head to the front. Young children competently learn balance, visual discrimination, and complex movements, but higher-order functions that are regulated by the frontal lobes are the last to mature.[5] This evolving maturity accounts for the recklessness of adolescents, but also indicates that children are able to reproduce items they see and hear before they are able to understand them well. This ebb and flow of human cognition presents opportunities and challenges in teaching the young. Certain skills should be mastered in childhood, because later they require much more effort. However, young children may not understand or value the material they can easily learn. When national budgets and large-scale donor financing are considered, it may be more efficient to let children "parrot" material in the lower grades and focus on comprehension in the middle primary grades, when children become more competent at this task.

B. Nerve Wiring and Survival of the Fittest Memories

The neuron consists of *a body*, which contains the machinery to maintain the cell, a single *axon* which may have several endings, and several *dendrites* that extend away from the cell body. Electrical currents pass through nerve cells and provide communication.[6] The dendrites receive input from other neurons while the axon provides input to other neurons. A neuron communicates with another neuron by releasing a chemical substance (a *neurotransmitter*) from its axon. This neurotransmitter then passes through a small cleft (a synapse) and then gets attached to receptors on the surface of a dendrite belonging to a neighboring neuron.

Learning events result in the creation of proteins along dendrites and in communication among dendrites of one cell and axons of another. The strength of communication between two neurons is determined by the amount of neurotransmitters released from the axon terminals, how quickly the neurotransmitter is removed from the synaptic cleft, or by how many receptors the receiving neuron has on its surface. The incoming voltage must be strong enough or come from a sufficient number of other neurons to reach a threshold; otherwise the neuron will not fire. (Some neurons may actually send inhibitory signals directing the next cell not to fire.) Receptors accept neurotransmitters for very brief periods and then shut down. Overall, it is experience that modulates the amount of neurotransmitter released by one nerve and the response strength of the next.

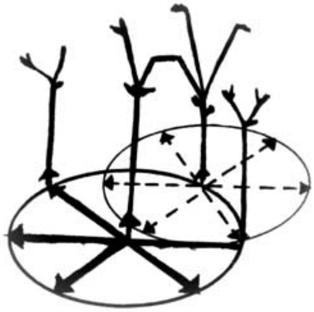
Irregularities in the amount of neurotransmitters available or the periods of time they can influence are related to various types of mental illness as well as changes in thinking that come with age. For example, NMDA, a type of receptor found in the hippocampus, regulates associative memory recall. At a young age it stays open longer facilitating new connections. As people age it closes faster and is related to the increasing forgetfulness of aging.[7]

Like an octopus, a neuron grabs onto some connections and releases others to create a pattern. Neurons do not usually act alone but operate in crisscrossed assemblies of constantly shifting patterns (Figure A-2). A particular neuron may be part of several such assemblies because new patterns are superimposed on already existing ones. Like blinking groups of lights, these patterns appear one moment and disappear the next (thus are called *spatiotemporal patterns*). Larger assemblies are formed for objects, actions, relationships, analogies, sentences, and so forth. Any given experience will form a unique pattern in time and space of neural activity across a given assembly of neurons. The spatiotemporal patterns are only evident when activated. The patterns corresponding to the memory of someone's favorite teacher, for example, will form easily because nerves have fired in that pattern often enough, but they exist in the brain only when the person thinks of that teacher.

The spatiotemporal patterns are formed on the basis of principles analogous to "Darwinian" selection: [8]

- A pattern of firing neurons arises.
- It is copied by other neurons.[9]
- Variant patterns arise.
- Patterns compete for space and neurons "willing" to fire along with them.
- Conditions make some variants more common than others.
- The most successful patterns prevail.

Figure A-2. Neuron Assemblies



Source: Adapted from Calvin 1997.

- Successful patterns become the basis for similar patterns of firing neurons.

Experience shapes the survival of the "fittest" pattern and makes it possible to perceive and think accurately. The groups of neurons with stronger synaptic connections among them form the memory. Competition winners have an advantage; they are "primed" to fire. The more often neuron assemblies fire, the faster they are likely to fire. The more recently neuron assemblies have fired, the more likely they are to fire again.

The more frequently firing patterns of neurons are activated together, the more stable the assemblies become. As they stabilize, they fire faster and more efficiently in synchrony. Frequent connections among nerves create new synapses or may strengthen or weaken the existing ones. Unneeded ones are eliminated. Metaphorically speaking, the brain is a sculpture carved by experience and education. The spatiotemporal patterns in students' brains are a direct outcome of curricular content, amount of instruction, and amount of practice.

C. Brain Architecture and Learning Functions

The modern world demands a lot from brains developed for stone-age needs,[10] and most seem able to rise to the challenge. A great deal has been learned about the relationship between learning and cerebral activity since the advent of brain imaging techniques in the 1990s. The most frequent such technique is functional magnetic resonance imaging (fMRI; Figure A-3), which monitors cerebral blood flow while persons do various cognitive tasks.[11]

Figure A-3. fMRI Equipment

Source: Adapted from Shaywitz 2003, p. 7.

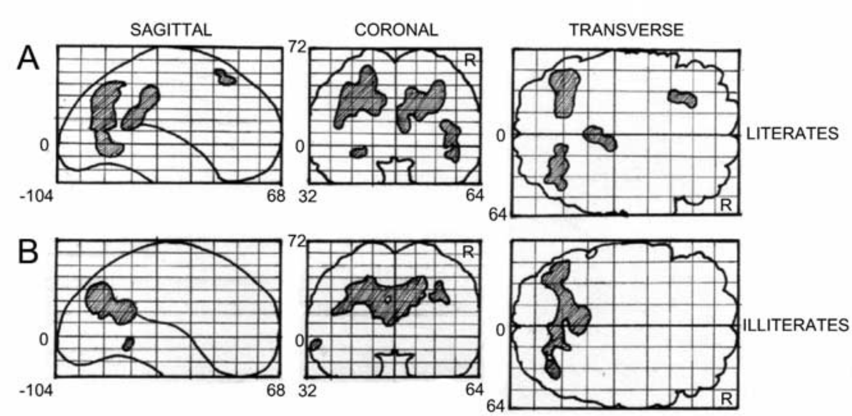
There are thousands of specialized areas in the brain, and these participate in different and overlapping networks of neurons. Various functions are carried out in multiple areas; often one is the main area and is associated with others playing a secondary role. Areas that serve similar or related functions tend to be located close together. This section briefly presents the areas mentioned in various sections of this publication.

The cerebral cortex, the folded outer layer of the brain, is mainly involved in higher-order functions such as conscious perception, judgment, and decision making. It is set up to categorize information, extract rules from events, and then discard many details.[12] Knowledge useful for dealing with the world is based on organized information. The left hemisphere is more involved in verbal functions (speech, writing, reading), while the right hemisphere is more involved in visual and spatial analysis (fine perceptual discriminations, intonation, fine motor-coordination). However, both hemispheres are involved in almost all cognitive operations.[13] The homologous areas of the hemispheres are connected and communicate through a band of tissue known as the corpus callosum. As students practice verbal and spatial tasks that connect the two hemispheres, the *corpus callosum thickens*. Other areas also become better connected, so literate people have connections that illiterate people lack. Thus the brains of literate people are wired differently from those of illiterate people (Figure A-4).

The cortex (Figure A-5) is divided into four lobes that are implicated in many educational issues discussed in this publication:

- *The frontal lobe* is concerned with planning, attention, problem solving, and short-term memory in relation to learning. The lower left part creates associations and becomes less active as people age.
- The forehead section of the frontal lobe, called the *prefrontal cortex,* integrates emotions and cognition and is involved in many expressions of

Figure A-4. Functional Magnetic Resonance Imaging Showing Glucose Utilization in Brains of Literate and Illiterate People



Source: Adapted from Castro-Caldas et al. 1998.

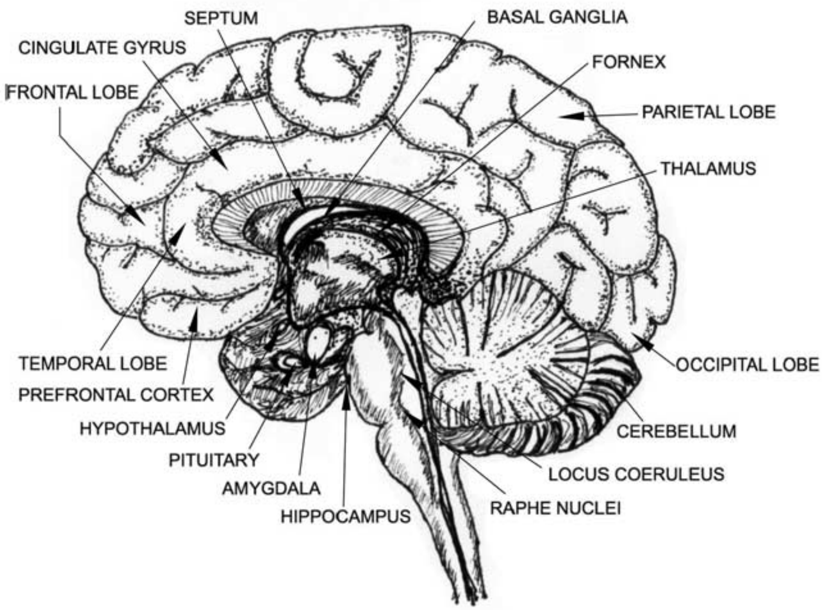
personality.[14] For example, it keeps a list of memories ready to use, like a checklist of items that must be done. It also contains mirror neurons, located next to the motor cortex, that provide a neural basis for observational learning.[15] The prefrontal lobe controls behavior when confronted with challenging situations, and juggles multiple pieces of information at the same time (a brain area still developing in teenage years).[16] The area that lies just behind the eyes and extends to just in front of the ears controls the ability to think flexibly.
- *The parietal lobe* is concerned with space perception and the coordination of movements.
- *The temporal lobe* is concerned with hearing and also stores much of the verbal and symbolic knowledge we acquire.
- The *occipital lobe* is concerned with visual object recognition and reading.

Subcortical structures of the brain. Many very important brain functions take place in areas that are below the cortex and outside people's awareness. Structures deep in the brain (including the limbic system) are responsible for encoding and consolidation of learning, motivation, emotions, and pattern computations (justifying to some extent the Freudian notions of the subconscious).[17] One of the ways they bring about effects is by directing the secretion of neurotransmitters in response to various mental states. The most important of such functions are presented below.

Memory appears to be a constructive process of combining the features of the items to be remembered rather than simply remembering each object in its entirety. Information scattered in the brain is integrated by the *thalamus* (see Figure A-5). This structure is responsible for encoding and binding of different modalities and qualities of our sensations and connects data about an object that are represented in different parts of the brain.[18] For example, the shape of a cat is represented in the occipital lobes; its sound is represented in areas involved in auditory perception in the superior temporal lobes, and its word meaning along with other concepts are represented in the inferior and lateral parts of the temporal lobes. If all the needed data are connected at the same time, we may remember something clearly, but if they do not, we may only come up with parts of the item we are trying to remember.[19]

If a brain structure is to be considered the "seat of memory," it is the *hippocampus* rather than the cortex. The hippocampus stores information temporarily and communicates with the cortex to arrange for storage, a process particularly active during sleep.[20] Thus, the hippocampus helps create long-term memories from items in short-term memory and then helps retrieve them.[21] The lower left frontal cortex is activated when associations are made, and specialized cells in the parahippocampal gyrus "save" the

Figure A-5. Brain Areas that Are Important for Learning



Source: Illustration by Christian Gerlach, Learning Lab Denmark.

associations in various parts of the cortex, in the specific associations the items have among themselves. fMRI scans show different brain activity when people remember something than when they have forgotten it, and it is possible to identify which words that a person has memorized from a list have been stored.[22] The hippocampus has estrogen and testosterone receptors and when the levels of these hormones drop in middle age, people have trouble learning new information (Annex II-L). It also has insulin receptors; thus consumption of carbohydrates or other substances that facilitate rapid glucose release improves retention. The effect of insulin on the hippocampus may be one reason why school breakfasts and snacks seem to facilitate learning, particularly among poor students (Chapters 2 and 4).

Emotions such as anger, fear, and the automatic fight-or-flight response are regulated by the *amygdala*. Although the details of emotionally neutral events tend to be forgotten, those of emotionally charged events tend to be remembered. To ensure that harmful actions are avoided, the amygdale regulates activity in many parts of the cortex; it makes people pay attention, influences social interactions with strangers,[23] and leads to an increase in the blood levels of stress-related hormones like cortisol and norepinephrine. Norepinephrine increases glucose levels in the blood, thus facilitating memory consolidation in the hippocampus.[24] Therefore material learned in an emotionally engaging context acquires connections to the amygdala. This is why information that causes fear or has negative connotations is remembered well and is not easily forgotten. If the level of emotional arousal is very high, then cortisol is secreted that leads to forgetting. For example, violent TV movies have been found to impair recall of television ads.[25] If stress is chronic, the hippocampus (see below) shrinks and long-term memory is impaired.[26] The intricate interplay between stress hormones and learning is acquiring increasing importance in teaching research (Chapter 4).

When skills (such as reading, driving, or touch typing) are learned well and practiced beyond mastery, control moves partly to subcortical structures that are concerned with involuntary and automatic functions. Automatized skills can be carried out with little or no attention paid to them, and unless substituted, they are normally not forgotten when their practice stops.[27] Humans have considerable capacity for gradual trial-and-error learning that operates outside awareness. Very important structures in regulating this type of learning (implicit memory) are the basal ganglia.[28] These are tightly connected to the prefrontal cortex and help it prioritize information.[29] They regulate habitual movements such as writing, smoking, or learning grammar rules. Another area involved in learning that is not directly controlled by consciousness is the *cerebellum.* It regulates physical coordination, balance, and motor learning, such as riding a bicycle or executing dance steps.[30] This area also supports activities of higher learning like mathematics, music, and advanced social skills.[31]

Feedback, reward, curiosity, and reinforcement mechanisms are still only partly understood. Implicated are structures such as the *cingulate cortex* (possibly involved in feedback), *ventral striatum*, *caudate nucleus* (monitoring responses), the *nucleus accumbens* (involved in social cooperation and surprises)[32] and the *ventral tegmental area*.[33] The *dorsal striatum* is involved in reward processing and made up of several areas involved in enjoyment and satisfaction, goal-directed behaviors, and in the processing of rewards that accrue as a result of a decision. Brain activation in this region has been implicated in making decisions or taking actions that are motivated by anticipated rewards. It also seems involved in feelings of pleasure that arise when punishing others.[34] Better understanding of this issue may help reduce the abusive behaviors of some teachers.

Conditioning and behavior modification involve these reward mechanisms and engage the amygdala as well.[35] These are fundamental mechanisms associated with all almost all types of learning. Classical conditioning pairs a conditioned stimulus (such as a shock) and the unconditioned stimulus (such as a tone) to obtain an automatic response from an animal.

Operant conditioning pairs a stimulus with a voluntary response that may lead to a punishment or reward. Motivated behavior is present whenever we perform an operant response in order to obtain a reward (be praised by the teacher) or avoid a punishment (get low marks). Novelty is also a positive reinforcer, possibly because of novelty detector neurons in the brainstem that detect sudden changes in the environment.[36] The nucleus accumbens (a part of the basal ganglia) is the primary structure responsible for these connections; it gets input from the amygdala and this is probably the main reason why the amygdala is responsible for stimulus-reinforcement association learning.

A very important function of the brain that is still not well understood involves the *unconscious calculation of frequencies and patterns.* The brain's "calculator" is capable of computing intricate statistics and figuring out social and linguistic relations and directing behavior accordingly.[37] However, little is known as yet about the locations and the rules of this calculator. Statistical calculation may happen at the neural level rather than in specific parts of the brain.

When awake and focused on an activity, a normal brain produces numerous fast brainwaves. People with attention deficits and cognitive process disabilities produce lots of slower brainwaves, like the ones generated when people sleep. Industrialized countries have programs and means to deal with children that have attention deficit or cognitive processing difficulties like retardation. Examples are neurofeedback games that train the children to focus, such as S.M.A.R.T. Brain Games (by Cyber Learning Technology) that use a specially designed helmet and computer equipment to engage students' attention.[38] But these are not affordable in poor countries.

D. Memory Systems

The memory systems and relationships among them are complex and are only partly discussed in this document (Chapter 4). Some additional information is provided below.

Strictly speaking, long-term memory is not a single mechanism. Different types of long-term memory systems store different kinds of information. It is not known exactly how the neural mechanisms of episodic and semantic memory differ. Some evidence suggests that retrieval of episodic memories depends heavily on structures related to the medial temporal lobes (for example, the hippocampus) whereas semantic memory depends more on the inferolateral parts of the temporal lobes.[39] Explicit memory and learning depend heavily on the frontal lobes and the medial temporal lobes. Implicit learning and memory seem to rely more on subcortical structures, especially on the basal ganglia, but also on the occipital and parietal lobes.

The frontal lobes are important for the intentional control of elaborate encoding and retrieval whereas the medial temporal lobes are important for automatically binding different types of information and for the consolidation of memories.

As with long-term memory, brain scans show that working memory functions as a network.[40] The acoustic store is mediated by the left parietal lobe. The rehearsal process (the articulatory component) involves more anterior structures of the left hemisphere. The visuospatial sketchpad is mediated by the parietal and occipital regions of both hemispheres with more anterior structures in the frontal lobes (predominantly the right) being important for active imagery. The central executive mechanism is not really localizable because it constitutes an umbrella term for various operations that may affect working memory, such as allocation of attention and level of processing. However, it is strongly associated with processing that takes place in the frontal lobes.

In effect the "front line" of memory is s*ensory memory* (Figure 3.1). As a stimulus is perceived, it goes momentarily into a space that stores appearing images or sounds; it has a very limited lifetime ranging from milliseconds to seconds. It roughly corresponds to the traces left by stimuli in the parts of the brain that register incoming information, such as the image that lingers on after people close their eyes. However, the amount of information we can remember from a visual scene is extremely limited and the source of that limit may lie in the posterior parietal cortex.[41] A specific electrical signal in the brain levels off when the number of objects held in mind exceeds a person's capacity to accurately remember.[42] A single spot in that part of the brain determines the size of the visuospatial sketchpad.

Because working memory handles the processing of information that vanishes in instants, one would expect that it would be related to intelligence. Indeed, the executive functions of working memory (assessed by tasks involving attentional control) have been found to predict intelligence, although short-term memory capacity (assessed by tasks such as memory for sets of words) has not.[43]

Working memory changes with age. British research shows that the working memory of preschool children differs in some respects from that of older children. In ages 5 to 8 years, the phonological loop and the visuospatial sketchpad were found to be still independent of one another. The verbal storage space exists in young children, but the phonological loop and visuospatial sketchpad are independent from each other until about ages 7 or 8. The actual phonological loop seems to mature about age 7; before then children do not usually rehearse material spontaneously. Short-term memory for visual material also increases and by age 7, children can recode visual images into the phonological loop and rehearse them.[44] Short words are remembered more accurately than long words because they can be refreshed more often during the fixed interval of working memory span. As children develop between ages 6 and 10, they process information more rapidly, which means that they rehearse the contents of the phonological loop of working memory faster, improving retention. In addition, they become more aware of how language works. Consequently, older children are better able to search their long-term memory for information needed to reconstruct material lost from working memory.

Assessing working memory span. Working memory span is relatively fixed in individuals. So, the "magic" number of seven items varies depending on the length of words in a language. The Chinese who have short words can remember about nine and the Welsh who have long words remember about five. Since visual memory is limited, only about five sign-language words can fit.[45] If people cannot rehearse information in their short-term memory buffer, data are lost after about 3–4 seconds.[46] If they actively rehearse data, short-term memory lasts up to a couple of minutes. Memory buffer size is tested by asking people to repeat a series of digits backwards or forwards at the rate of one per second. First, three digits may be read aloud, preferably in a person's native language. After presentation of the last digit, participants attempt to recall the digits in the correct sequence (for example, 5 8 3 9 0 2 4 6 2 5 7 3 1). If recall is entirely correct, the number of digits is increased by one. (Two tries are given.) This procedure is repeated until the participant recalls a set of digits inaccurately. Digit span is defined as the largest set of digits recalled perfectly.[47]

Education lengthens working memory span. Significant differences have been found in the number of digits recalled backward and phonological verbal fluency between those with 5–9 years and those with 10–19 years of education.[48] Though this research is correlational, experimental research has demonstrated the role of literacy instruction in expanding working memory.[49] Portuguese illiterate adults could recite 4.1 digits, subjects with four years of education could recite 5.2 digits and subjects with nine years of education could recite 7.0 digits.[50] Perhaps because of limited working memory, adult illiterates may have difficulty understanding fast and complex speech.[51] Morais et al. (1987) found that Portuguese illiterates performed worse than literates when asked to identify different words coming simultaneously in each ear (dichotically). People who know how to read may focus on the phonemic constituents of speech, thus recognizing ambiguous speech more effectively.

E. Nature, Culture, and Circumstances

Intelligence is not simply due to inheritance. It arises from the neural connections made during childhood in response to environmental stimulation. Some brains are better at adapting to the environmental challenges that they meet, and differences in intelligence are due to this readiness to adapt.[52]

Discussions about the education of the poor often raise questions in people's minds regarding students' intelligence. How important is this factor? What can be done to improve poor students' chances in successful schooling?

People have an ability to solve novel problems and an ability to apply knowledge and skills to make decisions. These two types of intelligence (fluid versus crystallized) are correlated with each other, but are distinct. The former taps the ability to acquire knowledge, and the latter taps the knowledge already acquired. Intelligence results from nerve functions that involve connections among neurons, amounts of neurotransmitters like acetylcholine, and speed of nerve transmission.[53] To a considerable extent these neurological features are genetically determined. The more efficient nervous systems have more complex connections and communicate at faster speeds. These processes are ultimately expressed as reaction time, attention span, short-term memory capacity, and reasoning skills. So, children whose brains are very good at adapting neural connections to the environment would be able to form the appropriate connections and process many kinds of information more effectively than other children of the same age. They would appear to be bright or gifted.

Neuronal connections are relatively differentiated when a child is born and become progressively more elaborate over childhood until maturity.[54] Specific mental abilities depend largely on the volume and pattern of gray matter found at the corresponding parts of the brain.[55] This is why intelligence is sometimes seen as a profile of linguistic, logical-mathematical, musical, spatial, bodily-kinesthetic, naturalistic, social, or emotional abilities.[56] Schools mainly exercise the linguistic and logical-mathematical abilities, so persons gifted in other "intelligences" may not excel in school. Since people use multiple abilities in life, mediocre students may become successful salesmen, and the best students may make wrong decisions.

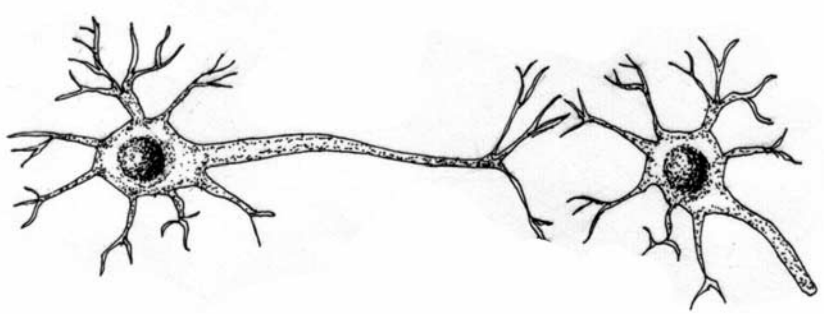
At maturity, many neural connections stop developing, and it is possible that there is a critical period for intellectual development. Thus, if people are to acquire various intellectual abilities, they need to be exposed to appropriate stimulation during childhood, while the neural circuits are still malleable.[57] This is one more important reason why early childhood education is important for the poor.

However, genetic expressions merely provide a broad range. With it, people perform according to training and circumstances they have encountered in their lives. For example, different cultures may value certain psychomotor or perceptual skills, such as weaving baskets or sorting rice, which intelligence tests may not capture (Annex I-F and I-G). Overall, many of the skills associated with intelligence can be taught and mastered with practice (though some people may need more instruction and more practice than others). Training and education can help people reason more intelligently, and can help them to overcome some of the biases and pitfalls humans are prone to.[58]

The ability of the brain to change in response to stimulation (Figure A-6) was demonstrated in the 1980s through experiments comparing rats that were raised in poor environments (in cages with minimal stimulation) with those raised in enriched environments that had complex mazes and challenging toys. "Rich" rats were found to have 20–25 percent more synapses per neuron in an area responsible for visual integration in the cortex than rats raised in the deprived environment. This increase was accompanied by a change in the number of blood vessels and cells that support the metabolism of neurons and the growth of new synapses between them. Rats apparently used the enlarged nerve cells and support cells to solve maze problems more effectively than rats without such modified cells. The effect increases as the duration of exposure to the stimulating conditions is extended. Conversely, cortical neurons decrease in size when there is less input to them. Decreased stimulation may diminish a nerve cell's dendrites, cortical thickness is readily reduced with an impoverished environment, and at times the effects of impoverishment are greater than those brought about by a comparable period of enrichment. Rat studies suggest that there is a critical threshold of environmental stimulation below which brain development may suffer.[59]

Because the brain adapts to circumstances, it adapts to the information and stimulation available in recent decades; so, every new generation acquires more competencies, and intelligence test scores increase by 3–7 points every decade.[60] Early and varied stimulation helps multiply neuronal networks related to academic skills, changes brain architecture, creates linkages for more knowledge, and gives an advantage to children with interested and educated parents. There are no inherent reasons why the

Figure A-6. Stimulation Facilitates Connections among Nerve Cells



Source: Illustration by Christian Gerlach, Learning Lab Denmark.

poor should be genetically less intelligent than those who are better off. However, nutrition and knowledge availability may sharpen the mental differences between socioeconomic strata.

The heritability of IQ really depends on socioeconomic status. In impoverished families, 60 percent of the variance in IQ is accounted for by the shared environment, and the contribution of genes is close to zero; in affluent families, the result is almost exactly the reverse. [61] This suggests that the poor are more influenced by environmental situations. Nutritional and health problems that adversely affect brain development are more prevalent among the poor (Chapter 2). As a result, children raised in poorer homes are at risk for lower IQ scores and may do worse on other measures of cognitive development by the age of 5. The longer children live in poverty, the more severe and longer lasting are the consequences.[62] Also, expectations and stereotypes can modify performance. For example, announcing Indian students' caste has been related to a 25 percent reduction in post-test performance among low-caste students.[63] Conversely, the effect of teachers being told that certain students were potential "bloomers" resulted in higher than expected performance.[64] Brain plasticity makes it possible to develop new neuronal connections and recuperate functions to some extent or catch up. Studies of Romanian orphans demonstrate the ill effects of severely restricted environments, but suggest that even in these cases, rehabilitation is possible.[65]

Most students with lower innate intelligence are able to perform satisfactorily in countries that provide extensive schooling, individual attention, and many options. Thus, in middle-income countries a few IQ points confer little extra advantage in life. However, in countries that have few real hours of instruction, dearth of materials, and indifferent teachers, a few IQ points may make the difference between literacy and illiteracy, or progress to higher levels versus an unending cycle of poverty. This is why nutrition, school health, and early language development are critical components in the schooling of the poor (Chapter 2).

F. Cultural Differences in Students' Cognition

Despite apparent individual differences, human cognition has the same principles worldwide. Whether in Canada, Samoa, or Thailand, children's reasoning seems to pass certain milestones at about the same age. (For example, children in diverse cultures are able to reason at about age 5 where someone might search for a misplaced object.)[66] However, the brain's response to different environmental needs results in some cultural differences. Some ethnic groups living in certain parts of the world have learned to discriminate and perceive differences that other groups do not need, such as estimating the amount of produce in a pile, getting sailing directions from features in the sea, finding one's way in the Amazon forest, or deciphering animal tracks on the ground for hunting.[67] Would school-level effects result from cultural differences in perception or cognition?

In some cases they may: Western cultures have had formal education for decades, and students may be more adept at remembering the abstract and decontextualized information that schools demand. In other cultures the context may affect much more the probability that material will be retained. Parents in industrialized countries may also teach children skills in more verbally formalized ways than indigenous parents, where role modeling and direct experiences at an early age are very important.[68] The extent to which these differences may affect learning in school in certain areas is unknown. However, some studies have compared neuropsychological variables among various cultures, as discussed below.

Maps and figures. Culture significantly influences common nonverbal psychological tasks, such as copying figures, drawing maps, or listening to musical tones. Studies have shown that map drawing and copying figures are heavily dependent on culture and practice. Depth perception in pictures also is influenced by culture; in a study of African figures, virtually all European children perceived depth around the age of 12 years, but even Guinean and Bantu children as well as illiterate laborers responded to the pictures two-dimensionally.[69] Nonverbal intelligence tests that rely on drawings, therefore, may be more influenced by culture than expected.[70] For these reasons, there is a strong association between educational level and performance on common nonverbal neuropsychological tests.[71]

Speed of execution. A small sample of Zambian children were compared to U.S. children and were found to have lower performance scores in language, attention, and executive function, though higher scores in copying designs. However, they also worked at a slower speed.[72] Similarly, Zairian children were found to be slower in a tactual performance test than U.S. and Canadian children,[73] while Spanish children (particularly girls) were found to be slower in a trail-making test as compared with U.S. children.[74]

Perceptions of time. Western and Japanese people in particular are especially time conscious. Latin American, Indonesian, and generally more collectivist cultures tend to be less time-oriented.[75] Perceptions about time stem from association with others, and they may involve relative social comparison judgments. It is probable that these perceptions affect how important it seems to teachers to fill classroom time with on-task teaching. Absenteeism may be due to a perception of how much is acceptable in each country.

U.S. and Western European rhythms are driving curricular development and Education for All implementation. If students and teachers are slower at executing various functions and do not have the time to do the work and carry out the curricula, this must be better understood. Slower execution speed may be to some extent one reason why reading automaticity takes longer in many countries than one would expect.

G. Gender-Related Issues in Cognition

Almost two-thirds of the world's adult illiterates—64 percent—are women. Despite much progress worldwide, girls accounted for 57 percent of out-of-school children of primary school age worldwide in 2001, and for more than 60 percent in the Arab states and in South and West Asia. Girls' participation remains substantially lower than boys' (a gender parity index below 0.97) in 71 out of 175 countries at the primary level. Of 83 developing countries with data, half have achieved gender parity at the primary level, fewer than one-fifth at secondary, and only four at tertiary.[76]

A cross-national European study found no gender differences in reading performance of grade 1.[77] However, systematic gender-based differences exist. Men and women perform similarly on IQ tests, but various parts of the brain mature at different rates in boys and girls. Women have more connections between the two hemispheres, and in certain regions their brains are more packed with neurons. Women use more parts of their brain to accomplish certain tasks. Men do their thinking in more focused regions of the brain. (This may be one reason why many more sufferers of dyslexia, autism, attention deficit, and schizophrenia are male.) Women seem to have stronger connections between the amygdala and regions of the brain that handle language and other higher-level executive functions, so they are more likely to talk about their emotions. Men's retinas may have more cells designed to detect motion, whereas women's has more cells to detect colors and textures. So, women are better at object location and may see colors and textures that men cannot; they also hear and smell things that men cannot. Men are better at mental manipulation of spatial information; after secondary school they score better in math and are more interested in science. However, girls perform much faster at timed tasks, particularly during the preteen and teen years.[78] Overall, performance differences are general, and innate brain functions are significantly modified through interaction with the environment. In Iceland and Sweden women tend to outperform men in math, and in other countries the gender gap is closing. Women have been shown to improve spatial reasoning substantially by spending about two hours a week for 10 weeks playing the game Tetris.[79]

Gender differences have led some educators to believe that the strengths and weaknesses of each gender should be better developed in single-sex schools. [80] However, within-group differences are larger than between-group differences, and the implications of gender differences on teaching methods are limited.

Differences in attendance and performance are often due to social factors rather than innate differences. For example, female teachers in West Africa help increase enrollment rates and reduce dropout, a feature that may be related to sexual harassment by male teachers.[81] Data from Guatemala suggest that family decisions to keep girls out of school often seem related to cost and labor issues and may not be related to school quality, whereas decisions to send boys to school may be related to quality.[82] And girls' lower performance in low-income countries may be related to iron deficiency and malnutrition that may affect them more than boys (Chapter 2).

II. The Lens of Cognitive Science

Before the advent of neuroscience, cognitive psychology tried to understand how the mind works through experiments of people learning, recalling, and perceiving under various conditions. This section presents pertinent topics, integrated where possible with the newer neuroscience findings.

A. Attention

As a person becomes alert, neurons related to the task tend to fire in unison. A neuronal "chorus" emerges suddenly from the hum of normal brain cell activity and may synchronize various parts of the brain, enabling a person to pay close attention to one item during a flood of incoming sensory information. Some of the nerve cells in the cortex may be sending messages in unison to allow people to pay attention to a single stream of sensory input.[83] Attention is a system supported by at least three interacting neuronal networks involved in alerting (achieving and maintaining an alert state in preparation for coming stimuli), orienting (selectively focusing on one or a few items out of many candidate ones), and executive control (monitoring and resolving conflicts in planning, decision making, error detection, and overcoming habitual actions).

- *People can only pay attention to a limited amount of information at any given point in time.* The brain has finite cognitive resources,[84] and they decline with age. It is possible to perform multiple tasks of the same type but only if the amount of the attention needed is within someone's "cognitive budget." This "budget" depends on the ability to ignore distractions. Attention is more easily divided among tasks that are dissimilar. Verbal tasks interfere with other verbal tasks and spatial tasks interfere with other spatial tasks, but interference across these categories is less. Thus, it is possible to drive and talk at the same time, unless the conditions are difficult. A student sitting in a class and doing homework for another class probably does not pay attention to the lesson, but a student who is drawing or handling a tool can also pay attention to the lesson. When people divide their attention among too many activities, they may retain only the superficial features of concepts they were exposed to. These are forgotten more easily than "deeper" features linked to meaning (see subsequent sections).
- *Attention to multiple tasks improves with practice*, because automatized skills need fewer cognitive resources. When children learn to write, for example, they must pay attention to their movements, and the brain

strains to coordinate all the input that comes in. After considerable practice, the skill becomes automatized and is now supported by subcortical structures (such as the basal ganglia) rather than the cortex. Then students can listen and take notes at the same time. Beginning readers focus on recognizing individual letters and have few resources left for the meaning conveyed by the words. Meaning can be attended to only after reading has been practiced sufficiently and is at least partly automatized. This is why struggling readers understand little of what they read.

- *Speech grabs attention very effectively*, more than instrumental music and environmental sounds. The voices more easily enter into the phonological loop of our working memory, possibly as a result of auditory "novelty-detector" neurons in the brainstem that warn animals of unusual sounds.[85] Students must actively work to suppress interfering speech, such as lecturing or recitations coming from another class. The same working memory resources are used to store information and inhibit distractions; so the effort decreases the amount of attention students can allocate to rehearsal of and elaboration of material that that must be encoded and remembered. Consequently, it is important to prevent voices from other classes from intruding into instruction (Chapter 12). The special attention that speech attracts may make it easier to remember what teachers say better than what is written in books. This may also be one reason why students seated at the front of a class are perceived as having an advantage.[86] Storytelling, an ancient technique to teach material to others, seems to be a particularly powerful means to grab attention through a connected message whose end the listeners want to know. Material presented along with it or in terms of a simile is very likely to be remembered later.

People (and other animals) *give their closest attention to stimuli that are neither too simple nor too complex.*[87] When a stimulus is so simple (relative to the intelligence and previous experience of the organism) that there is nothing new to it, it will be boring and not attended to. When the stimulus is so complex that the organism cannot detect any pattern to it, there is also nothing to attend to, and it will be boring. The relation between complexity and interest therefore is an important dimension of classroom interactions. If students do not understand the material in the class, they cannot pay attention. They may daydream, act out, or avoid school.

Though it may not be apparent to laymen, the processes that drive learning are to some extent discontinuous. Attention is finite; short-term memory takes in a chunk of data, processes it, and then takes another. This is one more reason why classroom activities need to change frequently, particularly for younger students.

B. Storage of Information in Cognitive Networks

The practical aspects of memory have been studied for over a century. Research has explored the conditions that favor recall of verbal and visual memories, the reasons why forgetting occurs, and the extent to which learning of one skill transfers to another. The findings are generally consistent with neuroscience findings. They are useful in education because they provide a rationale for assessing whether events observed in a classroom are likely to produce memorable learning. Chapter 8 presents the implications of cognitive research for classrooms. This section presents the basics of the underlying research.

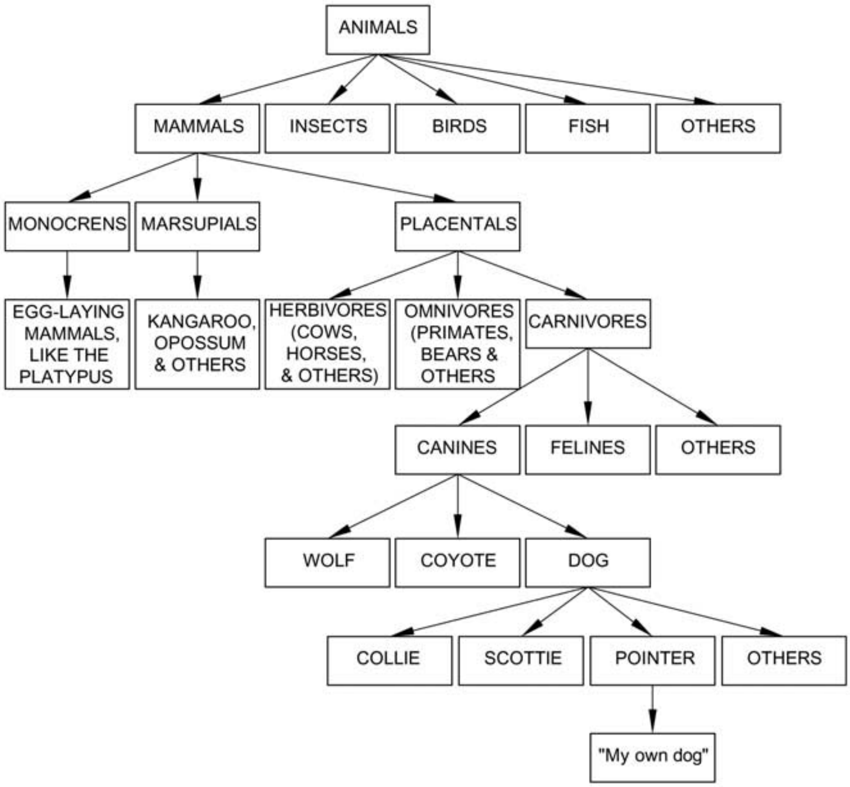
Many theories have been developed since the 1960s regarding the structure of knowledge (for example, human associative memory). Insight on the functions of neuron assemblies has created a revolution in cognitive science. The most recent developments are the "connectionist" models that focus on how knowledge is distributed in cognitive networks and model likely outcomes mathematically, through computer software broadly referred to as artificial intelligence.[88] Learning is expressed as strength of connections among nodes, as with synaptic connections.

Though the connection between neuron assemblies and cognitive networks is still tenuous, cognitive networks seem to mirror neuron operations:

- The basic learning unit is a connection (like a synapse) between two nodes of a network.
- Network nodes accumulate activation from other nodes or from external sources.
- If a threshold is reached, activation goes to other nodes.
- Once a node is activated, all links to it receive activation (or inhibition) simultaneously.
- Activation spreads down a path largely determined by prior experience.
- Nodes compete for inclusion in networks based on their utility.
- Many connections are made all the time, but only the most useful survive.
- The survival of an item depends on how and where it is encoded.

The challenge facing those who finance and manage schools is how to code information so that it is retrievable and so that it does not become "extinct." Information needs to be "installed" in learners' brains in such a way that it will be accessible whenever it is needed for personal decisions or the labor market (whether repairing cars or staffing banks). Some explanations about how networks work offer more insights.

Figure A-7. Illustrations of a Simple Cognitive Network

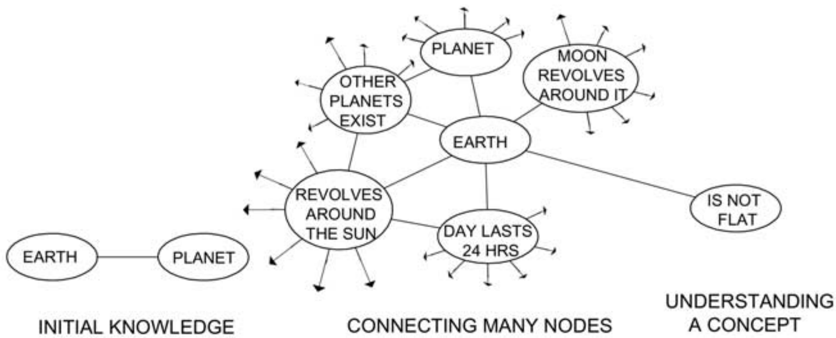


Source: Adapted from Slavin 1986.

Learning consists of accumulating links among nodes. Early on someone knows about item A only that it is connected with item B, but as more information is added, a network develops. *Understanding something* means finding the links between a new information item and the items one already knows. This means attaching an item to a specific part of an existing network (Figure A-7). *If people receive information that they do not understand* (for example, hearing a discussion among nuclear physicists), *they usually cannot attach it to existing networks and cannot retain it*.

Interconnected networks synthesize knowledge—up to a point. When existing networks interconnect, the result is more global knowledge and insight. The information items a person acquires are merely means to extrapolate knowledge about other items that are of interest but not known. For example, known historical dates serve as reference points to estimate when other events might have taken place. Activation excites larger parts of the net-

Figure A-8. Accumulation of Nodes to Create Complex Concepts



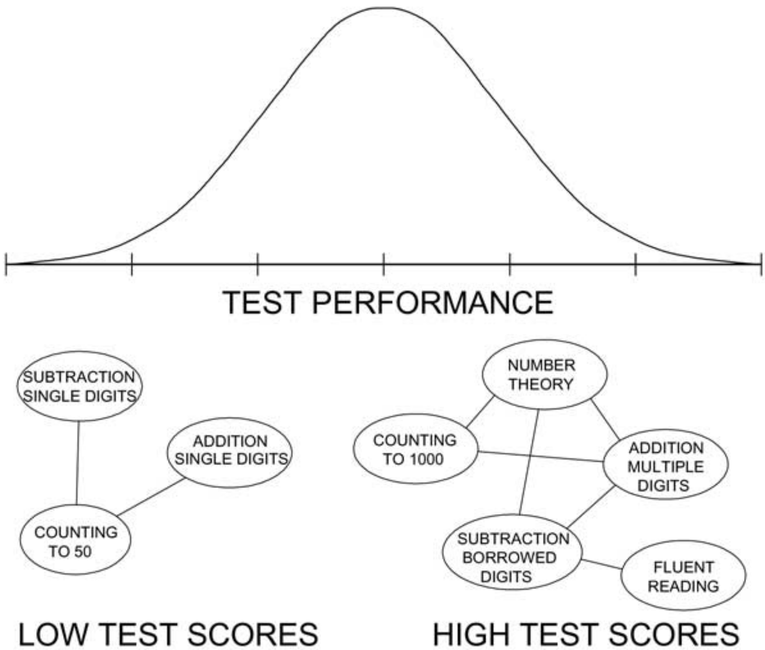
Source: Author.

work and much more information is available to a person than before. However, activation does not spread everywhere in the brain. If the entire system and all memories were activated at once, the mind would not be able to make choices. Organisms have limited energy, and activation at some point stops. Instead, experience leads to some paths more easily than to others, and often activation prevents entry to a part of the network. Though all parts of the network are in principle connected, access to many parts is difficult and possible only through tortuous roads. *To retrieve a piece of information, one must backtrack through the same paths followed when the item was encoded.*

Schooling adds to children's networks information compiled through curricula. Students who have more knowledge about a certain subject have in their minds more complex networks that contain more nodes and connections among them (Figure A-9). The students who have less knowledge about a subject have more limited networks with fewer connections among them or may have nodes that are not connected well. When tested, students must search through networks for answers. Those who have the more complex and interconnected networks with respect to a certain subject are likely to get better grades, while those with more limited networks are likely to get lower grades.

Neuropsychological research offers some glimpses of how these linkages are created in the nervous system. The same areas of the brain activated when something is learned are activated in reverse order when a person attempts to recall that event, seconds before the memory surfaces.[89] This phenomenon may account for the need to backtrack into cognitive networks to find information.

Figure A-9. The More and Better Connected the Knowledge, the Higher the Probability of Scoring Well on a Test



Source: Adapted from Reisberg 2001.

A mechanism also exists for linking information into specific configurations in long-term memory. New, or "short-term memories" consist of separate parts, which are stored in different regions of the cortex, depending on the type of information involved. These parts are initially linked through common connections they share between each cortical region to the hippocampus. During quiet time or sleep, some brain cells replay recent events, possibly to consolidate memory collected from various sources. As the memory is replayed during rest, direct links form among the various parts, thus making the memory independent of the links with the hippocampus. The hippocampus then reuses the cells for linking new memories. When one part of a recent memory is replayed in its cortical location, the other parts are, in fact, concurrently replayed in their cortical locations. This "concurrent reactivation" of brain cells is thought to be essential for linking the correct pieces of memory together into a coherent whole. Later, neurons that were active together during the task should be activated together, while neurons active at different times during the task should not be activated together.[90]

Knowledge begets more knowledge. Because of potential multiple connections, a little extra information may create a mushrooming effect of knowledge. The students who have more complex networks with respect to a certain subject find more nodes to attach new information that comes in and are more likely to retain it. Children who are better off and live in more stimulating environments may possess dense knowledge networks as well as anchors on which to attach more knowledge. Conversely, students with more limited networks about a subject have fewer cues with which to access new information and are less likely to retain relevant information to which they are exposed.

If the networks that children form in school connect in multiple places with the situations they will face in life, then curricula are "relevant" and children can use the knowledge in the labor market or in personal decisions. If not, students may acquire large domains of knowledge (for example, conjugations of Latin verbs) that may be tightly interconnected but have few connections with the knowledge networks used by most people. Then the curricula might be considered "irrelevant." This may also happen if relevant information is taught but is not tied to daily life needs.

How much new information are students likely to remember if they have limited prior knowledge? It is difficult to learn items that are completely detached from all networks. However, when someone receives information that is not well connected with previous knowledge, it is possible to open a new network and build on it. For example, one can memorize a poem and reproduce it verbatim. Children are able to repeat long sequences from memory and reproduce incomprehensible material that has few connections to existing information (also see Annex II-C).

But *information can only be retrieved along the path where it was coded*. Thus, material that is stored serially cannot be accessed in any other way; it can only be retrieved by going through the various nodes one by one. (Try for example to recall the third stanza of a poem.) If children only learn to repeat material verbatim, this information is not easily retrievable. It can mainly be retrieved through cues that match the neighboring nodes of the encoded information. To be answered, a question must be exactly phrased to elicit the first word in the series. When hearing the right cues, children may produce a satisfactory answer almost verbatim, but they are unable to connect it to other information networks and thus analyze, synthesize, evaluate, or apply the information. As a result, a child in Benin memorizing multiplication tables in French may still resort to innate number sense when calculating change when selling fruit on the street. Also, it may be harder to extract rules from memorized material. Overall, the speed and probability

Box A-1. The Sociology of Competition: How Knowledge Begets More Knowledge

Every society has its classes—the rich, the poor, and the middle class in between. A mathematical model of society based on each person's "fitness" (reflecting wealth or social status) suggests that when two individuals compete, the winner grows fitter, while those who lose become less fit. Thus, when encounters are few, everyone remains in a single category, but stronger competition leads to a hierarchy.[a] The existence of high-stakes examinations or overcrowding and competition for scarce teacher attention might lead to a similar result. In many areas, schools systematically seem to give the scarce resources to the best students, depriving others and thwarting efforts towards Education for All. The extra attention may help propel those who have a slight advantage far beyond their classmates. (In education this is sometimes called the "Matthew effect.") Some examples are given below.

To control classes and keep children quiet, teachers in Niger are trained to avoid choral responses. Children are asked to read one by one from the blackboard or the few textbooks that exist. The better students are asked to read first, so that the others will model after them. But in large classes there is no time for everyone to read. Thus the teachers identify those few who know how to read and work with them, while leaving the rest uninvolved.[b]

In Jamaica, "nonstarters" may be ignored by teachers so that those who have a chance at passing the school-leaving exam can receive their attention.[c]

In remote rural schools of Bangladesh, where instructional time is severely curtailed due to teacher absenteeism and school closures, students with the potential of passing the fifth grade leaving examination are often tutored as a matter of priority, although the majority of students may receive little instruction.[d]

In Kenya, a sample of schools serving very poor students received textbooks for use in the classroom. There was no difference in achievement between schools that had books and those that did not. However, the students scoring in the top 20 percent showed significant test score increases. Those students may have been the ones able to read fluently, understand the language, make sense of the message, and therefore learn from textbooks.[e]

Sources:
a. Redner and Ben-Naim 2005.
b. OED 2005.
c. Lockheed and Harris 2005.
d. Tietjen et al. 2004.
e. Glewwe et al. 2001.

that a concept taught in school will be recalled depends on interlinked factors, which are explained below in greater detail.

Sections 1–9 below elaborate on the following topics:

- how the classification scheme taught in school interfaces with students' existing networks
- conditions under which a concept was learned
- number of nodes in the network connected to the concept
- distance among various nodes connected to the concept
- semantic "depth" of connections
- how distinct a concept is from others
- strength of connections, how often nodes of a concept have activated in the past
- presentation order of a concept in comparison to other concepts
- perceived utility of a concept

1. The Mind Comes Prepared to Categorize and Extract Rules

If you keep paying attention while reading this material, you are opening new nodes in your mind. Under these you are classifying what you read. Depending on how the text is phrased, you open nodes under one category or a slightly different one. To fill the nodes, some phrases work better than others. Information seems easier and clearer to us when the relevant material is presented together, so we can fill the nodes quickly in an orderly fashion. A conclusion helps us classify the material under a higher-level heading. But if a document or a speaker flips back and forth in time or among various topics or gives too much detail under some topics, then our working memory overflows with loose items. We tend to find the document confusing, tiresome, boring. We may lose interest and stop reading the material. We may not act on its suggestions and soon forget the text. But if you find the material responding to your own information needs, you are more likely to retain it. Sometimes very well-presented material may give students the false impression that they have learned it.[91]

Why is a "logical" order needed in a presentation or lecture? The cerebral cortex has the genetic propensity to categorize facts[92] and to do so on the basis of meaning. Thus long-term memory has a hierarchical structure. For each concept the memory contains a "prototype" (for example, what a basic chair looks like), a set of examples, a set of beliefs about a concept, and an understanding of how these beliefs fit together. Even the simplest concepts have linkages that determine how they work (Figure A-10). Such concepts are classified under multiple categories, and we retrieve them

Figure A-10(a). Items Linked in Series, Like a Poem

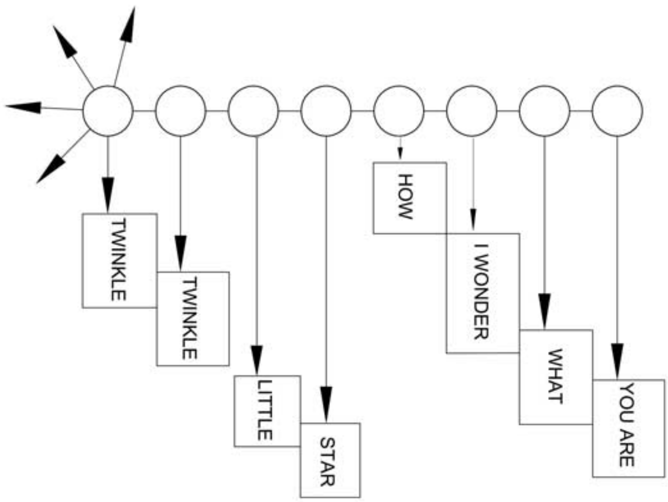
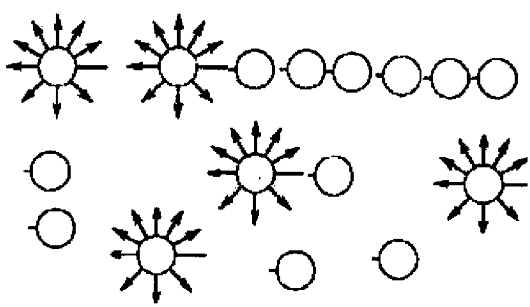


Figure A-10(b). Various Types of Links



Source: Adapted from Reisberg 2001.

Note: Each link in the chain functions as a cue for subsequent links.

according to context.[93] The more connections an item has to others, the more likely it is that it will be retrieved.

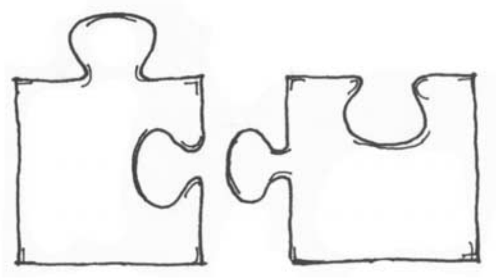
People usually do not recall information verbatim: the energy needed to maintain all the information would be immense. Instead, the cortex is set up to extract rules from information and discard many of the specifics. Thus, we remember properties of classes rather than individual data, and we reconstruct the details. This is why people asked to recall a story sometime after they heard it may forget the details but they remember the "gist." Similarly, a list of items to buy from a store is better remembered if the items are grouped in categories. Categories and the skill to produce them shift with time. Children age 5–8 may link words to existing knowledge on the basis of similarity and sound rather than inductive reasoning [94]

The mind prefers to create categories that are neither too general nor too specific.[95] Constructs at an intermediate level are remembered best; too many details are tedious, but constructs that are very general are hard to differentiate. To link knowledge, concepts are stored with connections as high as possible in a hierarchy. Given that the mind unconsciously calculates statistics, statistical relationships may be calculated on the basis of several examples, but little is known about the mechanics of this calculator.[96]

The tendency of the mind to extract rules rather than remember specific details has important implications for instruction. Students need exposure to events that can be used to extract rules. Questions that set minds on searches connect networks (what, how, why, when, and where). Deductive reasoning and explanations of the underlying rationale are critical in helping extract overarching principles that may then be better remembered and generalized. A study of classroom activities in industrialized countries has offered empirical support that students taught to reason while solving math problems may score better than those who mainly practice specific rules and procedures.[97]

Encoding specificity. Information is encoded very specifically in the brain along with the context in which it was presented. The type of memory trace determines what retrieval cues will be successful at gaining access to the memory trace (Figure A-11). For example, perceptual practice with an auditory presentation of a word does not help students if they later need help with a visual presentation of the same word.[98] Perceiving the concept "hot" does not help someone perceive faster the concept "opposite of cold." Similarly, practicing the completion of the missing letters in 'ELEPHANT' (_L_P_A_T) does not help people complete the other missing letters (E_E_H_N) faster. Educators often do not realize how specifically concepts are encoded and may underestimate the importance of this limitation. This memory feature however, may be responsible for the powerful effects of metaphors and similes in the retention of information that might be lost without such "packaging."

Figure A-11. Information Is Retained Better when it Fits Closely with Prior Knowledge



Source: Author.

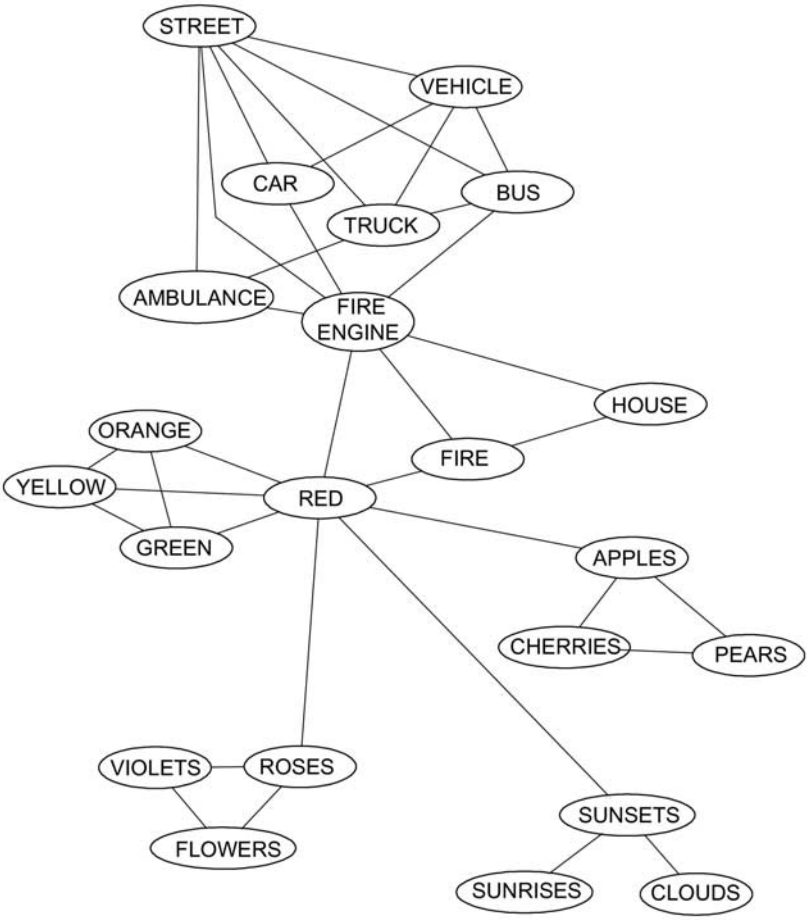
Semantic distance among concepts. As mentioned above, we recall information by backtracking on the path where it was encoded; thus an item located along a simple path will be recalled faster and more reliably than one located further (Figure A-12). Remembering concepts that are "distant" or encoded in convoluted ways takes longer and happens less frequently. Creativity or "out-of-the-box" thinking happens when people make extraordinary connections and reach existing information through a different path.

Like adults reading a document, students need concepts presented to fit clear categories. The next concept to be learned in a class, therefore, must fit in at least one of the categories in students' minds and be connected to a high-level concept in the network. *But the fit must be very precise and appropriate to the context* (encoding specificity). What happens if students miss school often or return after a long absence? *Absenteeism creates gaps in the contents of cognitive networks*. The class has gone on building network branches which the absent students lack. Thus, they may have no nodes specific enough to hang new information on to. Unless they learn the material they missed, they cannot easily retain the new information. Even if they memorize the material into relatively independent networks, they cannot relate it to their existing body of knowledge. Without extra tutoring, students who are frequently absent are at risk for failure.

2. Material is Recalled Best Under the Circumstances It was Learned

As discussed earlier, the sights, sounds, and smells of a memory are not clumped together in one place of the brain; memory is distributed across

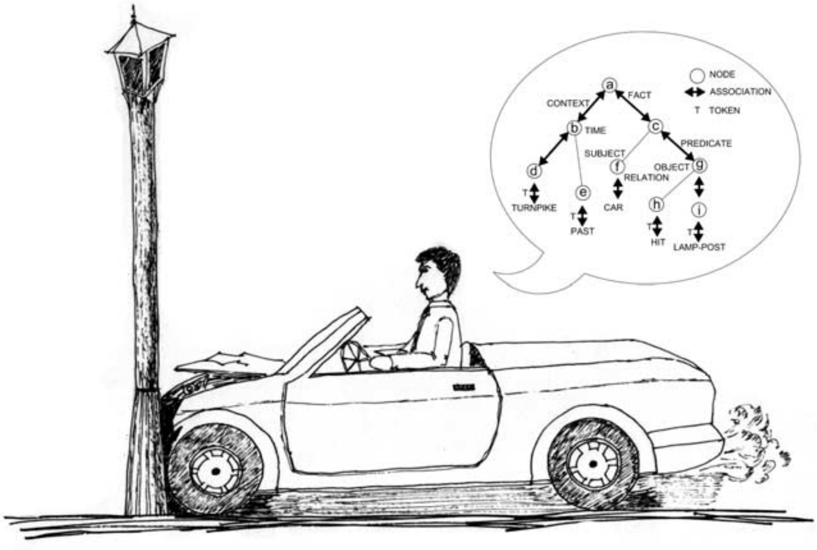
Figure A-12. Some Concepts are Semantically Closer or More Distant Than Others



Source: Adapted from Collins and Loftus 1975.

different areas and can be reawakened through just one of our sensory channels.[99] Thus, the environment seems to bring about cues. When people try to recall a concept, activation spreads along the network paths and activates nodes adjacent to the target concept. One memory brings related memories. For example, many people recall a language they have forgotten when they return to a country where they learned it.

Figure A-13. Information is Encoded along with the Context in which It Was Received



Source: Author.

State-dependent learning. When people learn something, the environment, the emotional state, or drug influence may be encoded along with the information (Figure A-13). Later, this information acts as a "priming" cue for retrieval. People are more likely to recall material in the place or the emotional state that they learned it in. The more such cues present, the more likely it is that information will be recalled. Even students who learned material in noisy environments recall the material slightly better in the same environment, although overall noise disrupts learning.[100] For example, students who read an article in a quiet place did best if tested in a quiet place (67 percent correct answers versus 54 percent correct answers if tested in a noisy environment. But students who read an article in a noisy environment scored 62 percent in a noisy environment (versus 46 percent in a quiet environment). Nevertheless, students who original learned in a noisy environment had lower overall performance.[101] Brazilian street children have been found capable of performing mathematic operations when engaged in sales in the street but unable to perform similar operations in a school context.[102]

The fact that recall depends on environmental cues may be one reason why *workshops, study tours, and inservice training often have limited impact on* *job performance* (Chapter 15, Annex II-M). For classroom-based learning, state-dependent learning presents a problem because material should be ideally recalled when needed outside the classroom. We may overestimate students' ability to produce information when needed if we probe it in the presence of priming cues and in the environment where it was learned. The solution is to present in class examples that generalize the use of material. There is also a need to make students think of material while outside the classroom, for example through homework, or by asking them to bring examples of pertinent concepts they witnessed outside school.

3. Well-Connected Information Can Be Located Through Many Paths

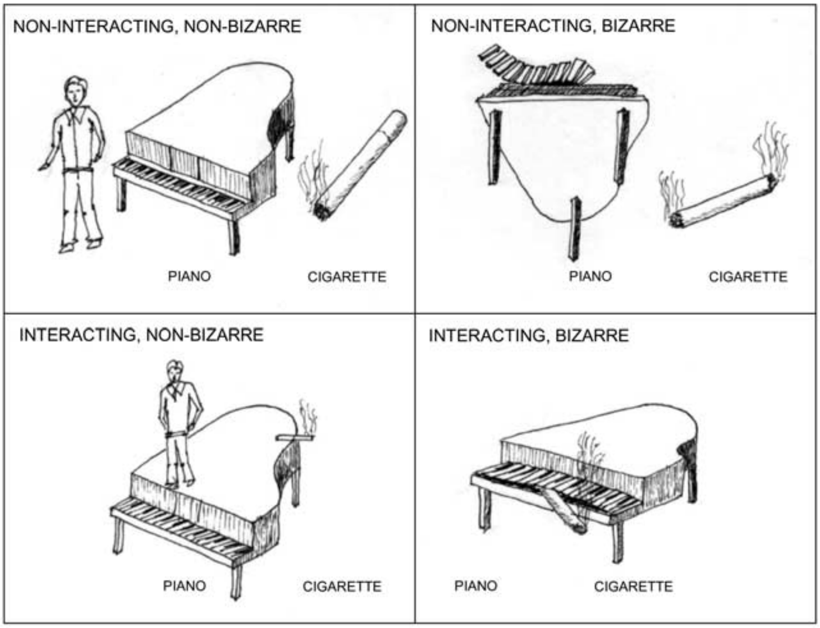
*Multichannel learning***.** Information is recalled more easily if coded under multiple categories. An item that has few if any connections is likely to be lost, while an item linked to the right parts of the network will pop out when people need it. The more sensory modalities involved, the more likely it is that the information will be retrieved. Keeping students engaged in activities that consolidate information through multiple senses is an effective teaching practice.

Images make material more memorable. Pictures and schematics greatly enhance comprehension of a text and provide additional information economically. For example, judgments on features like size can be made with pictures faster than with words.[103] Hearing information along with reading it may also enhance comprehension by creating connections into visual and auditory networks. Songs carry a lot of cues, such as rhythm and rhyming to connect words, and sung lyrics tend to be better remembered than spoken lyrics.[104]

For example, foreign language instruction may result in less usable learning if the learner relies mainly on written text rather than exposition in native speech (for example, through recorded conversations). Another modality useful for connecting material to be learned is *kinesthetic*. Examples from adult literacy are the use of finger movements or rising and clapping when literacy participants hear a certain letter. (Also see item 4 below.)

The storage of pictures and mental images occupies about the same areas of the brain. (Space perception overlaps only partly with the visual parts of the brain.) The overlap helps people remember dually coded concepts. Coding an image in a format that facilitates appearance doubles the chance that it will be recalled later on compared to merely writing about it.[105] Word lists are more easily recalled if the words are conducive to images, and instructions to use imagery during memorization improve memory performance.[106] Finally, visual images are useful for mnemonics. Particularly effective and distinct are interactive bizarre images[107] (Figure A-14).

Figure A-14. Bizarre Interactive Images Are Best Retained



Source: Adapted from Wollen, Weber, and Lowry 1972.

The educational value of videogames. Visual and spatial memory are underused in schools. Yet, poor rural children in India and elsewhere have shown intricate visual and auditory pattern recognition abilities when learning to use computers and video games (Box 13.1). Why do videogames capture attention and engage children for hours while other activities do not? It is unclear. Perhaps evolution has set up brain reward mechanisms to aim for a quick response and immediate reinforcement inherent in catching or avoiding fast-moving animals. Video games involve implicit learning, and it is possible to use them to teach academic material, but it is a challenge. The significant elements of a videogame for educational purposes include: (a) challenge—clear, meaningful and multiple goals, uncertain outcomes, variable difficulty levels, randomness, and constant feedback; (b) fantasy—a character with whom players can identify, use of an emotionally appealing fantasy directly linked to the activity, and use of metaphors; and (c) curiosity for audio and visual effects as well as surprises and constructive feedback.[108] Clearly most school work produced by less educated teachers with limited prior knowledge or instructional aids fails to bring about this effect.

4. Information is Most Memorable if Encoded on the Basis of Meaning

In principle, information can be classified in the mind on the basis of meaning, sound, rhyming, or other characteristics such as appearance of an item or its location. Up to about age 8 children may connect words to existing knowledge by sound and similarity rather than by meaning;[109] but by age 12, information is most stable and memorable if linked to other items on the basis of meaning.[110] People trying to remember a word by thinking about its meaning rather than its sound have been found to recall 50 percent more words.[111] Connecting on the basis of other characteristics is considered "superficial," and information is more likely to be forgotten (Box A-2). The concepts in a class are more likely to be remembered if presented through "deeper" rather than "superficial" connections.[112] To remember important information, it helps to create links with other already known items. The following techniques are particularly powerful:

- *Mnemonics* pair well-known material with material one wants to learn, both visual and verbal. For example, students in all disciplines have developed rhymes to remember terminology, and it is possible to recall a large number of items by pegging the items to be recalled onto objects found in a location (method of loci). The first-letter mnemonics (abbreviations and initialisms) are also popular, as well as the words that they spell (acronyms).[113] Mnemonics are useful for material that has no organization of its own (for example, such as linking letter shapes to objects. But if material is meaningful, a learner can do better by focusing on organizing and creating multiple connections.[114] Also, there is a danger of forgetting the "peg" to which mnemonics are fitted because there are few other connections established with it.
- *Attaching memories to movements* (active experiencing.) To learn lengthy texts by heart, professional actors identify the emotion that a statement is to produce (for example, "now the character sounds happy") and connect material to the movements they make. A study used an adaptation of professional actors' learning strategies (previously employed only for theatrical dialogue) for the acquisition of both expository and narrative material by college students. Results showed that students using this strategy retained more of the essential content of each idea unit (and as many of the exact words) as students using an intentional memorization strategy.[115]
- *Generative learning*. Individuals tend to remember things better when actively involved in forming an idea. For example, if an individual is given a clue and asked to provide a one-word answer, she or he will remember that word better than if simply given the word and told to memorize it.[116] Enhanced memory also results from "eureka" moments

of sudden insight. This all-important feature of memory may be due to reconsolidation that strengthens existing memories and integrates them with new ones, possibly involving reward mechanisms. It is behind the *discovery-based methods* used in science, math, and other subjects. Creating *useful difficulties* for students may also help classify items as distinct. A study showed that students who took tests repeatedly recalled a text better some time later although they had studied it fewer times.[117]

People's tendency to retain most easily the information that affects them directly is the concept behind Paulo Freire's *"generative words."* Freire taught literacy by focusing on the words that described the poor people's predicaments and getting them to read those. Generative words are used extensively in reading instruction of adults and children in hopes that familiarity and context will facilitate fluency.[118] Such notable words are the names of learners and those of their relatives.

5. Information Items Must Be in Some Ways Distinct from Each Other

What are you most likely to recall six months after an event?

- My cousin entered a bank
- My cousin entered a hand-gliding contest

  or

- Last October you went to a restaurant and drank water.
- Last October you went to a restaurant and drank an exotic fruit punch imported from Mongolia

Box A-2. Levels of Processing

The connections made during learning have consequences for subsequent recall:

- Shallow connections: superficial characteristics of letters and so forth—hardly noticed
- Medium depth: rhyming, serial connections—registers in memory but easily forgotten
- Deeper: related to the knowledge network—good chance of remembering an item
- Deepest meaning: related to self—rarely forgotten

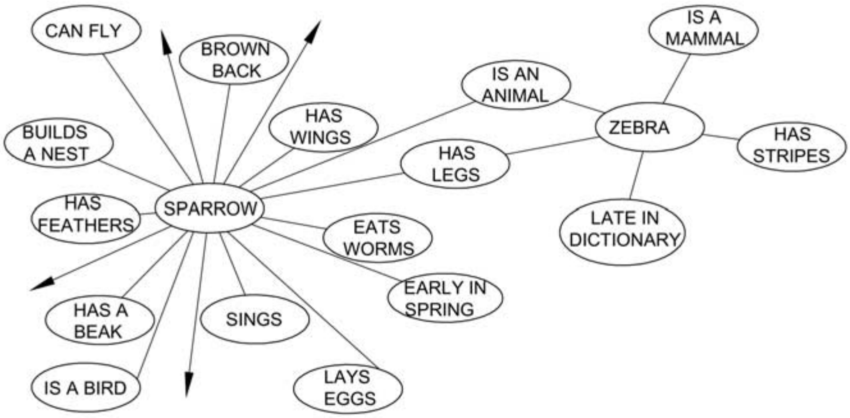
Source: Solso 1988.

As we learn more, new knowledge interferes with old. In the multitude of information we get, very familiar concepts should be the easiest to recall, but may also become hard to distinguish (including events in time that are subject to reconstruction). This is because they have connections fanning out to a large number of nodes. In cognitive science terms this means that though activation spreads simultaneously to the nodes of a network, there is less energy to go around when it is fanned to many connections. The response may be slower or peter out before the right connection is reached.

The "degree of fan" is a concept that shows countervailing forces in memory (Figure A-15). Too much or too little "fan" makes concepts hard to recall. If we know next to nothing about a concept (such as an advanced mathematical function), we may not code it effectively and may lose it (or be able only to recognize the word upon hearing it). But we may encode more details about concepts about which we know less, and thus these may be more distinct and easier to recall. On the other hand, a well-connected concept is likely to receive activation from more than one node and thus be recalled too often. But then details about it may be discarded, so we may not remember when we last used it and why.

Surprising, unexpected items are recalled easily. This may be related to secretion of stress-related hormones that facilitate consolidation (Chapter 4). Pleasure centers in the brain (like the nucleus accumbens) react more strongly when the pleasures are unexpected. The mind seems bored with predictable material, and people may find unexpected pleasures more rewarding than expected ones.[119]

Figure A-15. Concepts With High and Low Degree of "Fan": A Well-Known Sparrow vs. a Lesser-Known Zebra



Source: Adapted from Reisberg 2001, p. 246.

Making concepts distinct is a challenge in classes with few if any instructional materials, where students sit tightly packed in rows listening to the teacher. Even if they manage to pay attention all the time, they have few opportunities to think about the material. If it is remembered at all, it may just be coded as very similar utterances by the teacher about a subject.

6. Strengthening Connections by Contemplating Information

Just like neuron assemblies, the networks that have often been activated in the past are more ready to be activated again. Thus, the most practiced concepts come up when someone tries to recall information. Sometimes the connections are weak, and an item cannot be recalled immediately. However, concepts are encoded together with related information, so activation of one concept may activate related others nearby. A search for information "*primes*" the system and sends activation down the path where the sought information is encoded. The activation may later increase to the point of making the connection and recalling the information. Thus people have the experience of remembering an item sometime after they tried to do so.

Because of the mind's ability to recall items when primed, people's responses are faster if a stimulus word is preceded by a semantically related word. The related word will also give the context, and a person is likely to remember the word in that context.[120] For example, mention of the New York Stock Exchange is likely to make someone think of the stock market, not a horse market or a supermarket. Teachers very often give cues, sometimes pausing before a term to let students answer: "This type of triangle is called …."

Since the most used network connections are most likely to survive, practice is clearly needed to stabilize the information students get in class. The practice should connect new information to multiple network nodes. Reordering items, connecting them with items learned earlier, or reproducing items in various permutations is called *elaboration*.

Because working memory lasts only about 12 seconds, elaboration must be done very soon after a concept is presented if it is to be remembered (unless it is written in a textbook and the student can read it later). If a teacher is lecturing and presenting material fast, the working memory buffer may constantly get new material that is not processed adequately before disappearing and may be lost. This is one reason why a teacher must present a unit and then give students time to carry out elaborative activities such as the ones listed below:

- discussion—reordering of concepts so that they fit the cognitive network better

- generating stories with the information
- tying new information to known facts
- reasoning—explaining how various conclusions were derived
- making up questions about what people wish to remember
- making designs or sketches of the material
- expressing the concepts through the motor networks involved in writing
- doing homework that focuses on meaning
- using imagery—picturing verbal material if appropriate
- peer tutoring—elaboration is one reason why the students who tutor also learn

During elaboration, relationships among various concepts are established or clarified. It has been found that elaborative information facilitates the retention of concepts when it helps clarify relationships.[121] By contrast, when teachers ask students to repeat information more or less verbatim (for example, repeat a definition), the relationships among the concepts are not clarified. Thus, the concepts may be easier to forget.

Text that is more elaborate is remembered better. For example, the word "chicken" would be more likely to be remembered in the sentence 'The eagle swooped down and carried off the struggling chicken" than in 'She cooked the chicken." Because recall involves backtracking on a retrieval path, more nodes are activated when someone tries to recall a richly elaborated sentence.[122]

The difficulty with elaboration is that it is *time-consuming*. When the curriculum demands much material to be covered, or instructional time is inefficiently used, teachers just present the basics and assign elaboration as homework. However, in many countries textbooks are available in primary schools only during class and not at all in secondary or higher education.

Box A-3. The Brief Window of Opportunity for Learning

Overall, when information is presented, **the first few seconds matter the most.** Items may be lost beyond recall under the following circumstances:

- if an item does not receive attention
- if not processed while in working memory
- if not sufficiently elaborated and contemplated
- if encoded incorrectly

Source: Reisberg 2001.

Thus, the opportunities for elaboration at home may be reduced to repetition. Seatwork should be useful elaboration (and may be so in countries like Cuba and Tunisia), but it is often associated with lower test scores.

The concept that knowledge must be manipulated in some way in order to be retained is not widely understood, either by children[123] or by adults. Learning may be facilitated if students are taught how memory works (called *metamemory*) and if teachers discuss learning strategies. It is important that elaboration as a concept and practice be taught widely in teacher training institutions of lower-income countries.

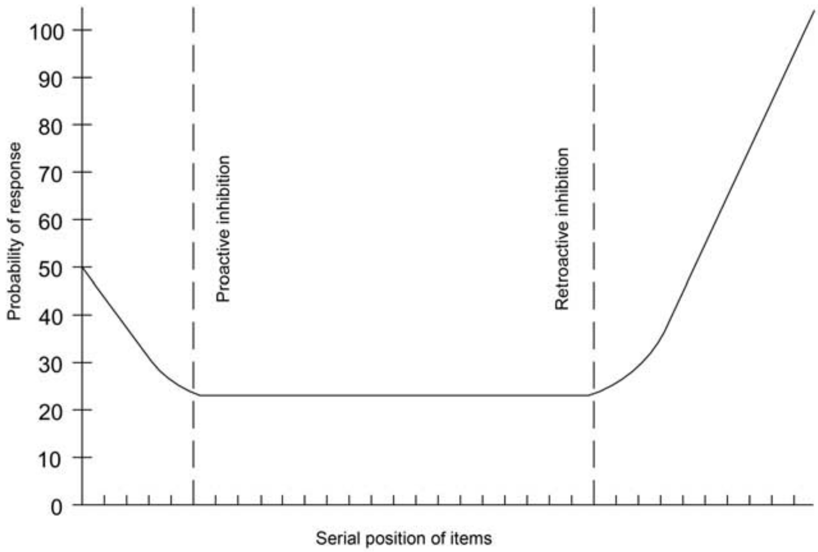
7. Presentation Order Affects Recall

Primacy and recency effects. We all have the experience of listening to long presentations and then recalling either the first or the last items we heard. This phenomenon is partly due to the constraints of the working memory. As explained earlier, it can keep only about seven items (or seven chunks of larger material) for about 12 seconds. While held in storage these must be classified. Early information is classified before the storage overflows. Information presented in the middle of a class or session, however, may not be closely attended to and may be lost before it is classified or may be coded ineffectively (unless it is very distinct). By contrast, the information presented last is not pushed out of the working-memory buffer and is remembered best (Figure A-16).

The primacy and recency phenomenon is also observed during longer periods, when items are encoded over a period of hours or days. It is probably due to consolidation processes that are still not well understood (Chapter 4). Its magnitude is large, and thus it is important. *Children may remember more of the material presented at the beginning or the end of the day or at the beginning and the end of a class. Adult workshop participants may remember less during the middle of a presentation.* It would seem that efforts should be made to make the concepts presented in the middle of a learning task more distinct, create multichannel encoding, and provide subsequent practice for reinforcement.

People learn better if they learn smaller bits of information over a period of days or weeks rather than all at once. (At the biological level, the limitations of consolidation during sleep may account for this phenomenon.) "*Massed practice*" results in good short-term recall but poor long-term recall.[124] Partly because of the primacy-recency effect, material should be distributed along a school year or a course, and introduced to a class a little at a time. Research[125] suggests that learning massive amounts of information may help someone pass an examination but the consolidation mechanisms will be overwhelmed, and much will be forgotten soon thereafter. This is true for simple as well as for complex material. For example, dis-

Figure A-16. Primacy and Recency Effects



Source: Adapted from Solso 1988.

tributed practice was found to produce better memory for material in lectures on statistics and typing of postcodes by post office workers.[126] In experiments testing very-long term memory as a result of time needed to learn material, the effects of distributive practice were dramatic. Spanish vocabulary was practiced 14, 28, or 56 days apart and totaled 13 or 26 sessions. Learners took a bit longer to master the material within each session when practice sessions were spaced farther apart, but this small investment paid dividends years later. Even 5 or 8 years later, the 56-day group always remembered the most, the 28-day group was next, and the 14-day group remembered the least. Further, the effect was quite large. If words were practiced every 14 days, learners needed twice as much practice to reach the same level of performance as when words were practiced every 56 days.[127] A meta-analysis of spacing studies showed that the average person getting distributed training remembers better than about 67 percent of the people getting massed training. Clearly, for durable educational effects, various items must be practiced repeatedly and frequently rather than just in one session.

Students in lower-income countries may be inadvertently exposed to massed practice because of teacher absenteeism or lack of training. A class may meet infrequently or be paced slowly until the month before the exams, when teachers realize that they have not taught what they should. In one such funded effort, teachers received incentives to give practice sessions to students. Though students did better on the test, they could not retain the massively practiced material in the long run (Chapter 14, Box 14.1).[128]

8. Information Deemed Useful is Remembered Better

The prefrontal lobe keeps track of memories ready to use and things that must be done, so people tend to remember more of the material left unfinished.[129] Perhaps for this reason, people are much more likely to retain information they expect to use. It is as if a node is opened in the network that begs to be filled.

Perceived utility presents a dilemma for students because so much of the information taught in school may only be useful years later. At best, certain information is useful to pass tests or to satisfy the teacher. Thus, filling students' networks with information also puts the information on a race to extinction. This is why the utility of information for students at their present but also future condition must be clearly explained in classes.

C. The Uses and Abuses of Memorization

Schools with few or any textbooks teach children through memorization. The ability to memorize accounts for transmission of culture throughout history. Because of children's ability to reproduce long sequences verbatim, it has been possible to pass long texts down through generations in societies with little or no literacy. Examples include the *sruti* tradition in India to transmit the Vedas, memorization of the entire Qur'an, and *griot* traditions in Africa. Memorization of certain texts may denote status and convey the message that a child belongs to a certain social group (such as the Homeric epics during Greek antiquity). To foster national or religious identities, schools may require the memorization of certain passages. And many children may feel reinforced and valued for their ability to reproduce complex text.[130]

Memorization has fallen out of favor in modern pedagogy, and for good reasons. Only a limited amount can be learned this way. Memorized items are connected not on the basis of meaning but on the basis of sound or "superficial" characteristics to those before and after them (Figures A-10a and A-10b). Thus, it is theoretically possible to commit to memory volumes of text without acquiring the knowledge that comes from contemplating these texts.[131] If the passages are retained, however, the text is available later for review and comprehension. Many people find it pleasant and

Box A-4. Useful Knowledge Tends to Be Remembered

Knowledge may remain unused unless specifically connected with parts of the network that can use it. Perfetto, Bransford, and Franks (1983) illustrated the effect by giving three groups of U.S. university students the following riddles to solve:

- Uriah Fuller, the famous superpsychic, can tell you the score of any baseball game before it starts. What is his secret?
- A man living in a small town of the United States married 20 different women in the same town. All are still living and he has never divorced any of them, yet he has broken no law. Can you explain?

Most people need hints to solve these riddles. One group of students received no hints. Two other groups received the following statements before seeing the riddles. "Before it starts, the score of any game is 0 to 0" and "A minister marries several people each week." One group received the statements without any accompanying comments. The other received the statements with an explicit instruction to use them later on.

The students who received the instructions to use the sentences scored nearly 100 percent on the test. But those who had received the sentences without any hint on how to use them performed just as badly as those who had not received any clues at all.

Source: Perfetto, Bransford, and Franks 1983.

useful to analyze texts they memorized as children. But background knowledge is still needed to understand the texts later.

For example, an IEG mission observed classes in Guinea repeating the definition of an article in French grammar until they can recite it fluently. To do this, students probably open new networks and accumulate as nodes the parts of the definition. *But without explicit connections to the body of French grammar, they may be unable to identify an article if they see one. All they can do is recite the definition when given a cue.* This is may be one reason why curricula in a class may be nominally covered, but when students take a test requesting the identification and use of concepts they have no links in their networks to help them respond.

How likely are students to remember and use later the material they repeated? The "superficial" serial connections are more vulnerable to forgetting, unless rhymes or some other features connect other to them. Repetition is essentially "maintenance rehearsal" people carry out when they need to keep items in working memory from being forgotten. If students memorize material and take a test, maintenance rehearsal can produce recognition of items but not much recall.[132] For example, in Niger, grade 6 students studying geometry were observed during an IEG mission repeating "an isosceles triangle has two symmetrical axes" (un triangle isocele a deux axes de symmetrie). But they were unable to explain what that meant; they were merely able to answer yes or no to a true-false question.[133]

One would expect teachers to structure topics on the basis of meaning, but not all do. Memorization may continue to be suitable when there are few if any textbooks and information can best be transmitted through repetition. Furthermore, some teachers are comfortable with repetitions and not eager to adopt meaning-based methods once textbooks become available. Perhaps the network structure is not obvious to people of limited education, as are many teachers. Another reason may be young children's tendency to classify concepts by sound and similarity rather than by meaning.[134] Students with developmental delays may continue to categorize by sound at later ages, so teachers may resort to the easily attained memorization. They may also find orally repeated results are easy to verify or they may be reinforced by hearing students repeat something they were taught. Finally, teachers may simply be doing what they have seen their own teachers do (Chapter 15).

The rejection of memorization in industrialized countries in favor of comprehension and higher-level processes has overlooked some important uses.[135] To carry out complex processes within the 12-second span of short-term memory, the mind needs to compile information fast. The availability of memorized items facilitates the job of the central executive function in the working memory that must assemble facts. For example, mathematics should be understood, but memorized arithmetic functions are needed as components to solve problems. These intermediate products should be memorized, automatized, and instantly brought to mind.

Choral responses are useful when the material is factual and amenable to rote repetition or very short answers. All children get the opportunity to respond and engage in an elaborative activity. By definition, they pay attention when they respond. By listening to their neighbors' responses, they may also get feedback and modify their own responses. This is particularly important in very large classes, where an individual student has little contact with the teacher. When an official language of instruction must be learned, choral responses provide some of the interaction necessary to help students master grammatical rules.

An important disadvantage of choral answers is that they are optional, and students may just not participate. They may have less incentive to pay attention as they must do in classes where they expect to be asked questions, and the weaker ones may not know the answers. Also, teachers requesting choral answers are less able to monitor individual student performance or whether a class has understood the material. (The numbers of voices should give some clues.)

Clearly, children's ability to commit information to memory must be exploited. The challenge is to create multiple connections for the material memorized, so that it can be brought up and used when needed for more analytical material.

D. Copying From the Blackboard and Note-Taking

Copying, necessary when there are no textbooks (as in Guinea and Niger, for example), takes up a large portion of class time. First the teacher copies on the board and then the students recopy. Students in higher grades and the university are expected to take notes as the professor speaks. Are there some benefits to copying?

Clearly some copying is needed in the early grades to develop writing skills and speed. Writing engages the psychomotor networks to consolidate the memory of letter values and spelling, and it may facilitate automaticity. Research on the forgetting of complex procedures and performance skills suggests that perhaps writing is not forgotten as fast when learners drop out before learning to read well. Because it is a time-consuming exercise, copying practice may be best reserved for homework.

Can primary school students learn and retain material while copying a lesson from the blackboard? No research has been done on this question. Those who are barely literate write slowly and laboriously, copying one letter or word at a time. Their working memory cannot keep these items long enough to form comprehensible sentences. Even if students partly process the material while copying it, they may encode just a series of words. It is difficult to encode for meaning and make connections with previous material in this way. Students also may copy without knowing how to read. IEG missions repeatedly have asked students to read aloud what they had copied in Guinea and Niger and got little or no response. Students with low-level literacy do not even copy correctly. In Guinea, only 41–57 percent of words were copied correctly in grade 2 and 47–58 percent phrases were copied correctly in grade 4.[136]

Advantages and problems of note-taking. For older students who write fast notes are a means of elaboration. Note-taking extracts meaning and imposes organization on the material. Note-takers remember more ideas about the major concepts in lectures and more often mention relevant concepts that were not specifically mentioned by a lecturer.[137] However, extensive note-taking during a lecture divides attention and may prevent deeper processing.[138] Students in low-income countries who habitually study in school without textbooks or in a foreign language may be slow and do this task inefficiently. Secondary- or higher-level instructors often spend class time dictating the lessons word for word or writing on the board (Chapters 11, 15). Thus class time that could be spent in elaboration is spent recording information. Given the limited practice students get with reading in some countries, they may not advance to succinct note-taking and organization of information until their university years.

Notes are sparse text, which, as mentioned earlier, is less memorable. Even when professors prepare and handout notes, the brief material they write may be much less richly encoded than material in textbooks. This finding presents another reason why students at all levels should have textbooks that they can take home (Chapter 11).

E. Transfer of Learning to Other Skills: How Much Is Really Feasible?

Transfer of learning happens when previously learned material influences the acquisition of new material, usually positively but sometimes negatively. Because of *encoding specificity* (Annex II-B), transfer of learning is rather limited. For example, people may know how to solve a particular problem but fail to understand that the same strategy can be applied in a novel context. Sometimes transfer is limited by perceptual limitations. For example, perceptual learning is highly specific to the visual figures encountered during training. When people get better at distinguishing a vertical line from one that is slightly tilted, improvement does not transfer to other orientations, such as a horizontal line.[139] For this reason, fluency in reading does not transfer from one script to the next once a new alphabet is learned. People find it hard to decipher relatively similar scripts (such as Hindi and Bengali, Greek and Latin), even if they know the languages.

Information can be easily retrieved in a new context only if it has been learned very well or if the new context gives some of the right cues to retrieve the information. Students do not easily apply concepts outside a class or to new situations, unless they have learned them very well. They need prompting and help to create bridges across cognitive networks.[140] If they have learned the material very well, however, applying existing knowledge may have negative consequences. People may fail to find new solutions for new situations and consistently apply old techniques in inappropriate situations (a phenomenon called functional fixedness or response set). Not surprisingly, the best means to create transfer of learning is to teach students multiple applications of the material they learn.[141] Demonstration of multiple examples helps students extract rules of how concepts can be applied. Then the rules can be applied more flexibly to novel situations.[142]

F. How, What, and Why Learners Forget

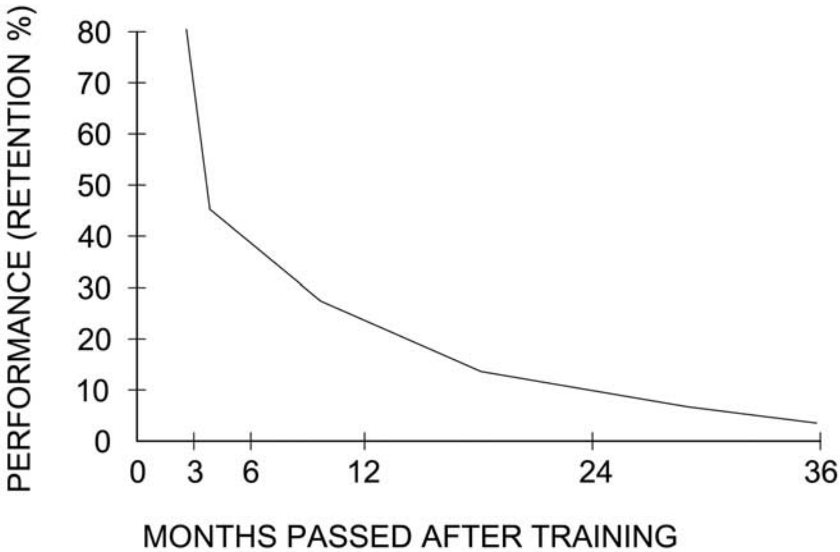
Memory does not usually just decay.[143] New memories interfere with old, paths to information are lost, and activation is insufficient. Sometimes events are actually overwritten by subsequent similar events.[144] Very negative emotions around the time of encoding may also interfere with consolidation and long-term retention (Chapter 4). Overall, there seems to be some rapid loss soon after learning that levels off according to circumstances. Generally, the amount of forgetting depends on the amount of exposure to the information.[145] If newly learned material is not practiced or integrated into existing networks, it will probably be forgotten (Figure A-16).

Forgetting of events (episodic memory) and forgetting of procedures (semantic memory) differ somewhat. Overall, episodic memory is remarkably stable, and years after an event, recollections or the gist of stories are fairly accurate. However, specific events and names tend to be forgotten, particularly if unpracticed. Instead, the mind reconstructs the past from the likely events that could have taken place. The reconstructive process leaves the possibility for significant biases, such as smoothing of inconsistencies. Forgotten material also leaves a vague sense of familiarity that makes people prone to memory errors and illusions. People forget what they forget, and they are often unaware that they reconstruct some details rather than recall them. Thus, it is common to overestimate what people are likely to remember and expect them to recall details accurately.[146]

The memories created through practice and application of rules (implicit memory and semantic memory) may be forgotten at different rates according to the skill involved. Lists of unconnected words (such as the experiments conducted by Ebbinghaus in the 1880s) show much immediate loss, with 50 percent forgotten within one hour. More general facts are remembered better,[147] probably because the concepts were connected with other knowledge and are frequently retrieved. Forgetting of a course content levels off after about 3 years; U.S. university students tested 10 years after taking a course were found to remember about 60 percent, though they had forgotten some names and specific concepts.[148] By contrast, complex procedures that do not connect well with other knowledge networks, such as cardiopulmonary resuscitation, are prone to rapid forgetting if they are not practiced (Figure A-17).[149]

Psychomotor skills are retained better. A study of military skills and knowledge of reservists called up for active duty during Operation Desert Storm found that procedural skills and knowledge about Army jobs decayed mostly within six months, but psychomotor skills (weapons qualifications) did not begin decay until ten months.[150] Previous skill qualification score was the best predictor of skill decay followed by aptitude score. Thus, there

Figure A-17. Forgetting Rates of Complex Procedures Across Time



Source: Adapted from McKenna and Glendon 1985.

seems to be a difference in the encoding and loss of psychomotor skills versus frequently and rarely used information skills. *Also, people who start from zero find it harder to retain what they have learned than people who are improving already existing knowledge.*

Even if the information cannot be recalled, material can still be recognized or can be relearned faster. Also retrieval is a potent event, more important than restudying previously learned material. The more difficult and involved the retrieval, the better the item is registered in memory thereafter.[151] This is why teachers must create "useful difficulties" for students (generative learning, Annex II-B).

These findings are pertinent to school situations. Well-connected and frequently used facts may be recalled relatively easily, but practice and active efforts to recall are needed to retain more complex procedures and skills. Children who come from poor backgrounds may have more difficulty retaining unpracticed material in school because they may have less complex networks on academic issues and may have to learn much more than those who are better off. On the other hand, psychomotor skills, such as writing or the operation of tools in vocational schools, may be durable longer without much practice and be useful to speed up learning in few courses.

G. Higher Cognitive Functions

As students master basic skills and attend secondary and higher education, instruction involves more high-level thinking. Higher-order cognitive functions are not represented by a simple network but by several subnetworks. Reasoning, problem solving, and creativity involve new connections among the subnetworks and formation of thoughts that are often not verbal. The issues are how to stimulate critical thinking and creativity and make students independent learners and thinkers.[152] The neurological processes responsible for higher cognitive functions are not well understood, and the advice is not yet clear on constructs such as interest and challenge that determine learning outcomes. For example, the neurotransmitter dopamine gets secreted in the early stages of events that involve short-term stress, creating the feeling of challenge in achieving something difficult, but little is known about the specifics of such states.

How can students be stimulated to think for themselves and become independent learners? Considerable psychological research has been conducted in the United States about this issue. Self-directed learners tend to ascribe achievements and failures to internal factors that they control (such as effort, ability, and motivation); at-risk learners ascribe failures to external factors that are beyond control (such as chance, luck, and others' actions).[153] Self-directed learners also regulate their behavior to meet academic requirements (for example, "If I write an outline first and then use the writing strategies I have been taught, I can get a draft done in 90 minutes"). Finally independent learners have *metacognition*, the ability to analyze, reflect on, and understand their own cognitive and learning processes. For example, students who know their weaknesses may use this quality to pick techniques that help adjust and compensate for them.

To foster metacognition and self-regulation, teachers must emphasize to the class the features over which students have control, such as amount of effort, note taking, perseverance, and sense of responsibility. They should provide opportunities for students to self-monitor, revise work, and reflect on their own thinking and learning processes. Teachers should encourage study skills, inquiry, questioning, and create an atmosphere where errors are acceptable during the process of arriving at correct answers. They need to be able to deal with ambiguity and avoid the shortest path to correct answers. They should help students to determine correct answers through critical questioning, expressing differing and conflicting views, and putting assertions and hypotheses to the rigor of disciplined inquiry (scientific method). The means to achieve these include journals, study groups, and critical peer reviews. Unless prerequisites and basic skills are learned during early years, children are less capable of focusing on higher-level functions in secondary school or even later. The challenge in low-income countries is to develop cadres of teachers who have these skills.

H. Learning Styles: Do They Exist?

It is often thought that different people learn best in different ways, and that schools and life-long learning courses should provide each person the opportunity to learn as best as he or she can. Many classifications of learning styles have been developed. Some people are believed to learn individually while others in groups, some more though hearing and others more through reading, some are self-starters while others need more guidance, some are incremental learners, "end first" learners, reflective or experimental learners, learners who favor one or more faculties (like language, number, or music, for example), social or solitary learners.[154] The multiple intelligences theory is based on these hypotheses.

Individual differences certainly exist. Some people are better at visualization, see more vivid colors, are better at rotation than others, have a more efficient working memory, or a faster nervous system. Thus they may be able to carry out tasks that most people cannot. But there is no evidence that information processing differs significantly among people. The various learning styles proposed are arbitrary rather than based on science.

However, different learning methods may be required for different tasks. To recognize new vocabulary, for example, it is enough to repeat it a few times, but to recall it, students must practice elaboration. Thus, learning styles may be more dependent on the nature of the task than on the abilities of individual people.

It is certainly desirable to accommodate individual differences in the way students prefer to learn in formal and nonformal education. However, schools in low-income countries offer few options for individualized attention to learning styles. The default presentation mode is "chalk and talk." This means that students better able to learn material verbally may be favored over those who could benefit substantially from pictures or kinesthetic means. Until provision of education is substantially expanded, the prospects for offering individualized instruction are rather dim.

I. Expertise and Its Implications

Once in a Greek secondary school in the early twentieth century, there was a shortage of teachers, so a theologian was asked to teach geography. The class studied Egypt and the fertility of the Nile river that can result in multiple crops per year. A student asked the teacher: is it possible for crops that are planted in the morn-

ing in Egypt to grow by noon? The theologian thought about it and said: not by noon, but surely by evening.

It takes about 10 years of study or involvement to become expert in a domain and another 10 years to make contributions in a field.[155] What is needed is not just knowledge, but the flexible application of a knowledge base that is well organized and highly interconnected. Experts and novices process the same information quite differently.

Novices tend to represent problems in terms of their surface issues, whereas experts tend to represent problems in terms of underlying principles need for solution. When solving a problem, the expert spends relatively more time than a novice on global planning or strategic planning and less on "local" planning—that is, the particulars of a problem. Because experts can recognize the deep structure of problems, they solve them by working forward to the solution, whereas novices are more likely to start with the known or intended solution and figure out how they can get to the terms of the problem.

Experts engage in *selective encoding*, distinguishing what information is relevant for their purposes. An expert can distinguish which facts are relevant and which, though interesting, are not really relevant. Selective encoding means that experts are able to detect important patterns very quickly; for example, expert radiologists may see an X-ray for two seconds and correctly pick out abnormalities. The experts figure out how to put together the different clues presented by an array of data to arrive at a diagnosis of a problem and also figure out which information they already have is relevant for solving problems presented to them. Experts also have much better recall of pertinent items of information compared to novices, because they have in their minds a collection of events that have happened very often. These are chunked in patterns; for example, chess masters asked to reproduce various moves do not place pieces on a chess board in an orderly progression but in grouped sets.[156] A requirement for the development of expertise is deliberate practice—that is, practice at the appropriate level that provides informative feedback and allows for error correction.

Although the development of expertise involves very refined patterns, there are some caveats. Memory is subject to illusions, partly because the short-term memory gives people very little time to consider data. These illusions, which have been studied extensively, affect decision making.[157] People often look for evidence that confirms rather than challenges beliefs. They tend to draw conclusions from very narrow samples of evidence, and those samples may fit what people already know. Statements made in positive or negative terms may differentially influence people's decision making.[158] Professional training does not make people immune to these phenomena.[159] Just like everyone else, experts can project their beliefs onto the evidence and perceive patterns that are not there. The risk of making such decisions that may prove misleading is high for the highly trained and well-meaning professionals, who often have little doubt and think they know the solutions.[160]

J. Ability to Act on "Lessons Learned" by Donors and Governments

Staff in governments and international organizations often discuss "lessons" that the institution has "learned." For example, if communities appear to be strong, they should be asked to share school building costs, but if they are weaker, they should only be asked to monitor teacher attendance. Or lesson migh be that research grant recipients should not be asked to do too much paperwork if the grant is to be implemented. The Independent Evaluation Group of the World Bank as well as the operations departments in each region regularly issue "lessons learned."

To implement these lessons at some future point, staff should demonstrate *prospective memory*. This means that they must remember that something has to be done in the future under certain conditions and without any explicit prompting. For example, one must remember to fertilize plants whenever they grow to a certain height or remember an appointment two weeks later. However, those who read the lesson are likely to encode it very differently from those who wrote it. The former may decode it as a piece of information received, while the latter encode it as many separate events and lessons brought together after a long time of looking for solutions. Therefore, those who developed the lesson will probably recall it more easily and in the appropriate circumstances, while those who read it may not do so.

In principle, staff should remember the lessons and match the circumstances described therein. Remembering under these circumstances depends on how distinctive the cues are that will signal the time and circumstances to carry out the planned action. However, cues of time and circumstances are vague, and it is unknown to what extent they bring up various lessons. Furthermore, the lessons are numerous; each project completion report of the World Bank contains 10–15 of them. The large organizations have thousands of staff, and it is uncertain to whom these lessons are directed. In large organizations, staff may feel less personally responsible about carrying out the lessons.[161] Furthermore, as people age their prospective memory declines. They may remember to carry out tasks that depend on an event (such as giving a message to someone when they see him) but not remember tasks that must be done at a certain time such as taking medications.[162]

If institutional lessons are truly to be learned, they should be few in number with clear cues as to when they must be implemented, and they should be directed at specific staff responsible for certain tasks. Staff might be more likely to implement them if responsibility or career consequences were involved. If these conditions do not exist, lessons may only be diplomatic tactics to deflect responsibility for unsatisfactory outcomes.

K. Age-Related Memory Changes and Their Implications for Learners

Research shows that there is good news and bad news in this field. Overall, the performance of "implicit" memory is constant throughout the life span. Neither crystallized intelligence nor judgment decrease significantly with age.[163] However, regions of the brain associated with executive processes as well as consolidation and recall (for example, the frontal cortex and hippocampus) show large and disproportionate age-related declines. In particular, the lower left frontal lobe that dredges associations with existing information becomes less active, and formation of meaning-based connections becomes harder. Genes that play a role in communication between neurons[164] are affected by aging relatively early in life, and their expression changes, affecting learning and memory.

Brain wiring develops until middle age and then begins to decline as cholesterol and iron levels rise in the brain. The myelin sheath around neurons starts to break down and triggers a destructive domino effect that slows down or confounds neuron communications.[165] Nerve cells do not die off in large numbers in the cerebral cortex, as previously hypothesized. Instead, large neurons shrink and smaller neurons increase. This could cause some decrease in the number of synapses. NMDA, a type of receptor found in the hippocampus, closes faster as people grow older and is related to the increasing forgetfulness of aging. Other culprits are the decreasing testosterone[166] and estrogen[167] levels that affect short-term memory. Also, high blood pressure, diabetes, and the problems created by smoking contribute to memory loss.[168]

The declines also affect attention and working memory. Older people cannot focus on one item clearly; they get easily distracted by other items, and may encode new information superficially rather than on the basis of meaning.[169] Thus, older adults may have difficulty in novel situations where they must respond flexibly to memorize things. On the other hand, this difficulty in focusing makes older people more capable of seeing the bigger picture.

Predictably, performance on explicit memory tasks is strongly age-dependent, with children and older people both outperformed by those in their middle years.[170] Memory is a slippery slope, whose decline starts in the 20s.[171] Some features become significant only in the 70s and above, while others become significant in the 30s and 40s. Declines involve tasks such as letter comparison, pattern comparison, letter rotation, computation span, reading span, cued recall, free recall, and recall of verbal items across a time delay.[172] Older adults forget specific details and rely on the general sense of what happened. Story forgetting begins in the 40s; word forgetting in 50s. Though significant, however, these declines are not very large. Older people recall only about 10–15 percent fewer items than younger people, and about 20 percent of older adults were found to recall as many words from a recently presented list as college students. Better-educated people show less decline; among people in their 80s, those with higher education retained 60 percent of words presented across a time delay as compared to less than 50 percent of those with low education.[173]

Learning physically modifies the brain by increasing the growth of new connections among neurons, and this process continues to the old age. Brain plasticity is an exciting find that has important implications for maintaining mental condition.[174] Also, cardiovascular health and physical fitness facilitate mental processes. Behavioral interventions including enhanced fitness and learning can contribute to improvements in performance even into old age. Specific training studies show improvements in spatial orientation, inductive reasoning, and complex task-switching activities such as driving.[175]

L. Training Implications for Middle-Aged Educators

Much of the memory research has been done with people past retirement age, but it is possible to extrapolate to intermediate ages. Many people who attend workshops are in their 40s and 50s, when sex hormones that influence the hippocampus have already declined to some extent. Thus, the ability to memorize is more limited, and entirely new networks with limited connections to previous knowledge may be harder to build. But the extensive preexisting knowledge of these adults means that they have many nodes on which to hang information that comes in. One hopes that experienced people who already know about a subject will rearrange knowledge structures as they see new items in a workshop, thus shortening the routes to information needed for important decisions.

Below are some possible ways to enhance workshops for middle-aged educators:

- When people want to remember an item, they have the tendency to repeat it a few times, which in younger people may serve to get an item through from the short-term to the long-term memory to be classified. However, in middle-aged people this technique no longer works well. They must be instructed to connect an item they want to remember visually with the pertinent knowledge or situation.

- A lot more attention must be given to meaning-based elaboration; participants must be made to *think about the situations where they will use the material*. To remember an item, one might bring to mind consciously the classification scheme where the item fits, with what issues it is connected, and if feasible visualize it in conjunction with items one wants to remember.
- Plan in detail what one will do with the newly acquired knowledge. State not only goals but "implementation intentions" or action plans that specify when, where, and how they will march toward achieving the training goals. Then people become more focused in their work and on-time completion becomes more likely.
- Visualization is an effective technique whose utility must be explored with appropriate cultural adaptations. Participants might be asked to visualize the situation in which the training information would be applicable. This is particularly important when training takes place outside

Box A-5. Visualizing Tasks to Be Done Could Improve Training Outcomes

While the frontal cortex deteriorates with age, brain areas specific to automatic responses stay relatively intact. As mentioned above, imagery stimulates the parts of the brain responsible for actual sensation, and images that can be named easily are better remembered. Thus it should be possible to bring about recall of a task at a specific time by asking people to visualize themselves doing that.

A group of 31 people over 60 were trained to track their blood sugar several times a day using a standard testing device, much like diabetics must do although the study participants did not have diabetes. Study participants were put into three groups: a deliberation group talked over the reasons why daily blood sugar testing was a good idea; a second rehearsal group recited the instructions for using the testing device; while a third imagination group spent *three minutes imagining themselves using the glucose monitor within the home or work environment*.

Results showed that the group visualizing an event was much more likely to remember to do it when they returned to their homes. Other visualization studies suggest the technique helps dieters stick to healthy eating, assists women in remembering to go for breast examinations, and increases the use of medic-alert bracelets by those who need them. The young and middle-aged can also benefit from visualization.

Source: Liu and Park 2004.

people's normal workplace and situational learning may prevent subsequent recall. *Visualization may also be effective in transferring skills from the verbal domain where they have been taught to behavioral networks and thus modify behavior*.

The problem is that with such activities, workshops become longer and more and more expensive. It seems much simpler to just present the material and trust the audience to learn whatever they think they need. But forgetting curves of complex procedures are steep, particularly when people are exposed to them for the first time. *A lot of workshop funds may go sliding down these forgetting curves*. Complex procedural training should best be given to people who clearly need it and who are likely to receive reinforcement in it. However, agencies receiving funds are often under pressure to disburse and may organize activities that leave little learning behind. Staff may be lectured on generalities that are not actionable or may be confused with other abstract topics. Ironically, evaluation reports later indicate that a certain number of teachers, principals, or other staff were "trained."

Workshop evaluation. Course evaluations usually focus on how much participants liked the training, how useful they found it, whether they would recommend it to others. While these features are desirable, they may measure episodic rather than semantic memory (or implicit memory where skills like computer operation are concerned). Because meaning-based encoding becomes more difficult as people age, people may remember training events as episodes (particularly if they are distinctive) rather than transform them into semantic memory.

If workshop observations are possible, observers using a snapshot instrument (Chapter 8) may rate the use of instructional time, degree of learners' apparent engagement, elaboration activities, and references to knowledge transfer at their workplace. Also participants may be asked later about their opportunities to use the information and its contribution to their work.

Table A-1. Improving the Effectiveness of Common Instructional Activities

Common classroom activities	*More "memorable" alternatives/better time use*
Teacher lectures "Chalk and talk" presentation	Teach in small steps of 3–5 minutes Include connections to other topics Use available audiovisual aids Use visual imagery if nothing else exists Tell stories, embed the knowledge in them
Individual questions and answers (including asking students to read)	Ask questions to all children at random, not just to a few Offer intrinsic rewards
Helping students search the knowledge they have, derive rules from facts	Ask challenging questions (what, when, where, why, how) Use analogies Focus on applications
Choral recitation or answers	OK for lower grades, simple information; ensure that all students participate
One student at the blackboard	Minimize time to 2–3 minutes Students should be doing same activity alone or in groups
Students doing seatwork by themselves	Substitute longer assignments with group work, set time, expect answers
Students working in groups	Assign students responsibilities to explain, make sure group mastered the task
Students doing projects (tasks that span multiple class hours)	Ensure high amount of instructional content, less "busy work"
Class copying from blackboard	Minimize copying except for teacher writing Use textbooks, instructional materials
Teacher monitors work	Ask groups to monitor each other
Teacher only working with 1–2 students	All other students should be doing work
Teacher giving instructions, handing books	Minimize transaction time, ask students for help

(Table continues on next page)

Table A-1 (concluded)

Common classroom activities	*More "memorable" alternatives/better time use*
Class waiting for bell to ring	Briefly review lessons, connect with other topics
Teacher talking to students socially or disciplining	Minimize amount of time and need for socializing and discipline Master known classroom management techniques
Teacher disciplining, not rewarding, students	Rewards needed every 2–3 good tries
Scheduled art, singing, play	If children have fallen behind, these activities should have minimal duration
Quizzes and exams given once a month or less frequently	Frequent (for example, weekly) tests compel students to review material and rearrange knowledge in new combinations; textbooks needed for this activity
Teacher must leave the room	Assign work, make certain students responsible for execution

Source: Author.

Table A-2. Policy Changes that May Improve Instructional Outcomes

Current policies	*Alternatives*	*Rationale*
Goal: All students should graduate from primary school by 2015	All students should leave school with basic literacy and numeracy, whenever they leave	Student dropout is substantial in some countries Instruction is too inefficient to provide end-grade-level knowledge to all
Early reading fluency		
No attention to how much students learn early on; reading is considered a low-level issue	Focus on reading fluency, shift resources to grades 1–2	Early fluent reading is critical for future performance; inability to read increases repetition costs and dropout
Grade 1–2 students have the same or less time and resources in schools May have the poorer teachers	Extra resources for lower grades to catch up, read, and calculate fluently; better teachers, frequent supervision	Prevent dropout with illiteracy; enable multigrade students to read fluently
Donor reliance on sample-based learning assessments to monitor progress, focus on later grades	Use rapid school surveys to monitor the skills of grades 1–2 for high-risk areas	Learning assessments take place years after inefficient instruction; governments rarely use the data
If many students fail, automatic promotion may be recommended	Remedy rather than promote automatically	Students unlikely to learn simple material in a higher-level class
If classes have more than 60 students, shifts may be split in some countries	Very large classes may be preferable to limited instruction	Opportunity to learn is all-important. Large classes might be managed through grouping techniques (experimentation needed)

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Table A-2 (continued)

Current policies	*Alternatives*	*Rationale*
Textbooks for classroom use, some textbook loan schemes	Textbooks for all students to take home	More practice, ability to recall complex material
Textbooks for primary students only No textbooks for secondary schools or teacher training institutions	Textbooks for all levels to take home Find means to get savings, loan schemes, and parental participation to get textbooks for the post-primary levels.	Without textbooks, practice is limited in the lower grades, and content is forgotten or never learned in higher grades. Teachers' time usually costs more than books
Mother-tongue instruction		
Deference to national policies French and English languages of instruction for all grades in many countries	Convincing countries and financing mother-tongue instruction at least for the lower grades, phase out in higher grades	Students may need 5–7 years to catch up with native speakers, particularly if foreign languages have complex spelling
Experimental programs in some countries carried out for decades	Formalize and extend the experimental programs Sensitize communities	Phonetically spelled native languages help achieve literacy quickly
Educator training		
Almost any training scheme for educational staff is acceptable to the donor community	Reform of teacher training based on learning principles highly pertinent to their work	Teachers may practice in classroom little of what they are exposed to in training
Lecturing about teaching	Correcting dysfunctional modeling behaviors, instilling effective behaviors (partly through videos)	Much teaching behavior is learned through role modeling rather than higher-order instruction

(Table continues on next page)

Table A-2 (continued)

Current policies	*Alternatives*	*Rationale*
Supervision and management		
Principals have limited supervisory authority over teachers and accountability for school performance	School-based management Knowledgeable principals encouraging teachers and providing frequent classroom feedback	Increasing the intrinsic motivational rewards that result from signaling a job well done and giving corrective feedback
Rare supervisions from district offices	Strengthen the supervisory chain and frequent teacher visitation	Teachers need someone to praise them, must work towards that goal
Limited interest in inspectors' and supervisors' reports	Retrain supervisory staff to submit reports on a limited number of instructionally significant variables	If higher authorities are actually interested in the reports and can do something about improving conditions, this may constitute an incentive for staff to supervise.
Community involvement		
Usually few systematic attempts to change parental perceptions on school-related issues	A communications strategy involving mass media to convince parents about the value of bilingual education, teacher monitoring, school involvement	Erroneous parental perceptions on instructional interventions may drive governments to reject valuable solutions for educating the poor
Community associations often ineffective in school supervision	Search for ways to improve participation Impart performance standards they must check for	Communities are present and interested, even if they do not know how schools must be run

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Table A-2 (concluded)

Current policies	*Alternatives*	*Rationale*
School health and nutrition		
Education projects rarely include school health or nutrition	Health and nutrition critical for information processing	Education and health ministries must learn to collaborate more closely
Usually no school feeding	Offer of food that does not require preparation, such as special high-nutrition cookies or milk	Food may keep children in school and is modestly related to performance; empower communities to deal with corruption
Early childhood education and development programs limited in scope	Improve effectiveness, engage communities (for example, through community-driven development)	More-developed brains are better able to learn basic skills
Encourage students to enter school at age 5–7, eliminate overage students	Explore the health and developmental reasons why students are overage	Overage students might be a result of cognitive delays but they are at risk of leaving school before graduation

Source: Author.

Notes

Chapter 1

1. In November 2005 the Operations Evaluation Department (OED) was officially renamed the Independent Evaluation Group (IEG). Aside from bibliographical references, the new name is used throughout the document.

2. PROBE 1999, Nkamba and Kanyka, 1998, Watkins 1999, and Menges 2003.

3. The performance of poorer countries actually overstates the population achievement levels, because OECD countries have universal education, while many children of lower-income countries are out of school or frequently absent and would not take a standardized test (Pritchett 2004).

4. Stevens 1993.

5. Schiefelbein 2005.

6. Educational psychology is the discipline that applies psychological research in schools, but it has focused largely on the issues of industrialized countries and on topics such as classroom management and students' emotional problems.

7. In the 1960s, when Mincer did his seminal work, U.S. public schools performed adequately, and variations in knowledge could be attributed to mere individual ability. Also factory workers learned repetitive tasks in orderly learning curves, further downplaying complexities in learning. Nevertheless, the Mincerian model has been challenged often. Cognitive skills acquired in school play a much stronger role than ability or simply years of schooling in determining earnings (Pritchett 2001, Glewwe 2002, Hanushek 2002, Coulombe et al. 2004).

8. For example, "Drawing on literacy surveys in Africa, it is useful to set the literacy level for children at five to six years of primary schooling" (Bruns et al. 2003). This contrasts with other countries where a functional literacy level is usually reached for a majority of children after three or four years of schooling" (Nordtveit 2004).

9. For example, the 2004 Annual Report of Development Effectiveness (ARDE) by the Independent Evaluation Group of the World Bank calls for a more balanced approach between social sector expenditures and infrastructure investments to alleviate poverty (p. xii). Spending more on health and education projects alone, for example, would not by itself reduce poverty.

10. In 2000, the Center for Educational Research and Innovations (CERI), an agency of the Organisation for Economic Co-operation and Development (OECD), launched the "Brain Research and Learning" project (OECD-CERI 2002). The U.S. National Research Council also produced a compilation of applicable theories and findings (Donovan et al. 2000, Bransford et al. 2000).

Chapter 2

1. Levinger 1992.

2. St. Sauver 2001.

3. Delaney-Black et al. 2002.

4. Baum et al. 2004.

5. Peruvian children living with inadequate water supplies and sanitation were found to be shorter and had more episodes of diarrhea (Checkley et al. 2004).

6. King et al. 2005.

7. Niehaus et al. 2002, Berkman et al. 2002, Jenkins et al. 1999. Jamaican children in grades 4–5 were treated either with placebo or an antiparasitic medication. All children were given a pretest and a posttest 10 weeks later to measure cognitive and fine motor skills. Compared to uninfected children, parasitic infection impaired performance on tests of memory and reasoning but not on tests of attention or fine motor skills. Treatment with albendazole did not remove the difference between initially infected groups. Therefore children whose cognitive functioning is impaired by whipworm infection need cognitive remediation and enrichment, not just medication, to recover lost cognitive functioning (Sternberg et al. 1997). The parasite load increases with age and iron deficiency seems to interact with parasitic effects.

8. The World Health Organization has identified worm infections as the greatest cause of disease among 5- to 14-year-old children. So, many school health programs successfully provide deworming medicine. For example, school-based mass treatment of children for hookworm in Kenya was shown to reduce student absenteeism by one-quarter (Kremer and Miguel 2001, 2004). In India, a program to provide iron supplementation and deworming medicine to preschool students decreased absenteeism by 7 percent among children age 4 to 6 (Bobonis et al. 2002). A WHO study in Indonesia that investigated the association between helminth infection and cognitive and motor function in school-aged children found that children infected with hookworm scored significantly lower on tests of cognitive function in comparison to uninfected children (citations in Birdsall et al. 2004).

9. Glewwe, Jacoby, and King 2001.

10. Disability statistics can be found at http://www.iadb.org/sds/soc/site_6190_e.htm.

11. Jyoti et al. 2005.

12. Although limited data exist, children in low-income countries undoubtedly are affected by dyslexia, autism, and coordination of fine movements (as is about 25 percent of the school population in OECD countries; OECD-CERI 2003b).

13. EPA (eicosapentaenoic acid) as opposed to DHA (docosahexaenoic acid) appears to be most effective in these conditions; after three months of daily administrations, children with reading difficulties, attention deficits, and delayed speech and motor development showed considerable improvement (OECD-CERI 2003b). Also, fish oil has been found to reduce the incidence of attention deficits and behavior problems in British students (Richardson and Montgomery 2005.

14. Block and Webb 2003. There are 39 substances that the body needs but cannot fabricate, so they must come from diet (OECD-CERI 2003b).

15. Tezic 1998.

16. Zinc was provided to seventh graders whose blood levels showed a deficiency. Those who consumed fruit juice supplemented with zinc reduced their reaction time on a visual memory test by 12 percent over 10 weeks, compared with 6 percent for students who received regular juice. They also had more correct answers on a word recognition test and better scores on a task requiring sustained attention and vigilance (Penland et al. 2003).

17. Hulthen 2003.

18. Horton and Ross 2003.

19. Tamura et al. 2002, Levinger 1992. Iron-deficient women may take longer to do tasks and be less successful at executing them. Those classified as anemic make double the number of errors in a memory task than an iron-sufficient group. Giving women daily supplements of iron for four months reverses this effect (Beard and Wong-Rieger 2004).

20. Gwatkin et al. 2000.

21. Brain volume is positively correlated with intelligence (McDaniel 2005).

22. Michaelowa 2001.

23. Berhman et al. 2005. Children should be breastfed for two years, and they only need about 150 calories five times a day. But poor parents often do not know how to feed their children (Rae Galloway, World Bank, personal communication, May 2005).

24. Simeon and Grantham-McGregor 1989.

25. Compared to a control group that did not have nutritional deficiencies, malnourished children showed a 41 percent increase in aggression at age 8, a 10 percent increase in aggression and delinquency at age 11, and a 51 percent increase in violent and antisocial behavior at age 17. The results were independent of psychosocial adversity and were not moderated by gender. There was a linear relationship between degree of malnutrition and degree of externalizing behavior at ages 8 and 17. Low intelligence mediated the link between malnutrition and externalizing behavior at ages 8 and 11 (Liu et al. 2003, 2004).

26. For example, Watson et al. 2001, Alderman et al. 2001, Alderman et al. 2003; Behrman et al. 2003.

27. Glewwe and King 2001.

28. Liu et al. 2004.

29. In Bangladesh, school-based food distribution increased enrolment by 20 percent compared to a 2 percent decline in nonparticipating schools over the same period of time (Ahmed and Billah 1994). In Jamaica, Tamil Nadu, and other countries where school feeding programs were evaluated, attendance and retention generally rose (Simeon and Grantham-McGregor 1989; Babu and Hallam 1989). In Kenya, a randomized control study demonstrated that children's school participation was 30 percent higher among students attending schools with feeding programs (Vermeersch 2002; see Birdsall et al. 2004 for citations).

30. Simeon and Grantham-McGregor 1989. Breakfast regulates metabolism, and children who go to school without it feel hungry all day (Dr. Kristy Nielson, personal communication, May 2005).

31. IEG evaluations in Guinea and the state of Sao Paolo in Brazil are examples (OED 2002a, 2003b).

32. A large survey study in the United States found dramatic black-white and social class differences in vocabulary by age 36 months. The gap stops widening when children enter kindergarten but remains constant; economically deprived children never truly recover (Farkas and Beron 2004). One possible reason is maternal malnutrition, given that malnourished mothers do not interact as much with their children or talk to them when they feed them (Rae Galloway, World Bank, personal communication, May 2005).

33. See Behrman and Rosenzweig 2004; Currie and Thomas 1995, 1999; Karoly et al. 1998; Murnane, Willett and Levy 1995; and Neal and Johnson 1996 for the United States. See Alderman et al. 2001; Alderman, Behrman, and Hoddinott 2005; Behrman, Alderman, and Hoddinott 2004; Behrman et al. 2003; Deutsch 1999; Glewwe, Jacoby, and King 2001; Glewwe and King 2001; Martorell 1995, 1999; Martorell et al. 1994; and Young 1995 for developing countries.

34. Gorman and Politt 1996.

35. See, for example, Campbell et al. 2002 and newer publications. The project creates a high-stimulus day of art projects and playground visits. Examples of effective learning games include waving a scarf over an infant until he or she grabs it, or leading a toddler to identify like items among several pieces of silverware.

36. World Bank 2004.

37. Global Monitoring Report 2005.

38. World Bank 2004 (www.worldbank.org/children).

39. Goodson et al. 2005, Farkas and Beron 2004.

40. See, for example, Evans et al. 2000. Curricula for developing countries have been developed through the Christian Children's Fund and the Step by Step program of Soros Foundation (and Children's Resource International). Language-oriented curricula in the United States include Breakthrough to Literacy (a McGraw-Hill product with interactive software (www.breakthroughtoliteracy.com), Building Early Language and Literacy (BELL), LeapFrog SchoolHouse (www.leapfrogschoolhouse.com), Learningames (www.kaplanco.com/resources/article_Learningames.asp), Tools of the Mind (www.ibe.unesco.org/International/Publications/INNODATAMonograph/inno07.pdf), and the Indian Sonu Series Teacher Manual for Supporting Young Readers by Nag-Arulmani 2004 (www.thepromisefoundation.ort/rpd_rk.htm).

Chapter 3

1. Teaching with role-modeling and feedback has been observed in a species of ants. The leader's performance greatly resembles teaching, with the follower acting as pupil. The lessons learned by tandem followers are transferred when they become tandem leaders. Though the teaching sessions are slow, they propagate time-saving knowledge among foragers (Franks and Richardson 2006).

2. The term "mind" often refers to the information-processing brain, particularly with respect to higher-order functions, such as analysis, synthesis, evaluation, or decision making.

3. Controlled processes demand attention, thought, and application of rules; they are slow and require serial or step-by-step processing. By contrast, automatic processes require little or no mental effort to execute, are fast, unavailable to consciousness, and can be done in parallel with other activities. It is because of these properties that automatic processes can be assembled into larger processing units. Many tasks start off as controlled processes (for example, tying shoelaces), but with practice, the sequence of behaviors can be accessed very rapidly (Logan 1988).

4. Pinker 1997, p. 341–342.

5. Schultz and Dickinson 2000.

Chapter 4

1. It is customary to divide memory into the encoding, storage, and retrieval stages. *Encoding* refers to the processing and consolidation of incoming information. If this information is maintained over a longer period of time *storage* has taken place. Finally, *retrieval* refers to the ability to bring forth this stored information at a later point in time. Research on consolidation shows that in reality these stages are blurred, but they are still useful in presenting applied memory research.

2. Attention span for children at various ages has been calculated at about 3.3 seconds at age 1, 5.36 seconds at age 2, and 8.17 seconds at age 3.5 (Ruff and Lawson 1990, cited in Bukatko and Daehler, p. 305). Research in the 1960s and 1970s suggested that attention span is about 3 minutes per year of age —that is, 12 minutes for 4 year olds, 14 minutes for 5 year olds, 18 minutes for 6 years, and increasing to almost 30 minutes for 8 year olds (Schaefer and Millman 1981).

3. The attention span may be facilitated by the amount of essential fatty acids a child has received from the mother's body or through breastfeeding. Infants from mothers with high levels of DHA consistently showed more advanced forms of attention all the way out into the second year of life; they were more engaged with complicated toys and less distractible during play (Colombo et al. 2004).

4. Dr. Barbara Rogoff, personal communication, May 10, 2005.

5. Video game players progressively increase their levels of attention and concentration on the goal to obtain rewards (Hubbard, 1991 cited in OECD-CERI 2003a). Clearly, the reward centers of the brain react in this particular manner, but details are unclear. This "immersion effect" can be related to Csikszentmihalyi's 1990 flow theory, defined as a state in which satisfaction occurs while one is "absorbed" by a certain activity. Concentration provides an opportunity to introduce educational content and have children learn it incidentally (Lepper and Malone, 1987, cited in OECD-CERI 2003a).

6. Schiff and Knopf 1985;Reisberg 2001, p. 108.

7. Bayley et al. 2005.

8. Nagy et al. 2004.

9. Deming et al. 2003.

10. Ardila et al. 1989.

11. Gathercole, Pickering, Knight, and Stegmann 2004.

12. Passolunghi et al. 1999, Jenkins et al. 1999. Students are asked to calculate while keeping words in their working memory such as (7x7)+1 = ? dogs; (10/2)+6 = ? cats.

13. In the United States, children with attention deficit completed a 40-day computerized program. Their parents reported that they had significantly fewer problems with attention and hyperactivity, both immediately and three months after the program ended (Klingberg et al. 2005).

14. Simeon and Grantham-McGregor 1989.

15. There is a relationship between the white matter structure of children's brains and reading performance. White matter comprises the bulk of the deep parts of the brain and is responsible for information transmission (Beaulieu and Phillips 2005).

16. Gavens and Barruillet 2004.

17. Bukatko and Daehler, p. 306.

18. Flavell and Wellman 1977, cited in Sternberg and Ben-Zeev, p. 311.

19. Kail and Bisanz 1992, cited in Sternberg and Ben-Zeev, p. 311.

20. Nicolls 2004.

21. The anatomical reorganization of memory representations is referred to as memory translocation. The field is changing rapidly, but for a review of modulation processes known at the time this document was written see Walker and Stickgold 2004.

22. Tronson et al. 2006.

23. Debiec et al. 2002.

24. Powless et al. 2003. Norepinephrine facilitates intermediate-term contextual and spatial memories, but not for the formation or long-term consolidation of emotional memories (Murchison et al. 2004).

25. Manning et al. 1998. Also the hormone leptin, that conveys satiety feelings after food, has an effect on the hippocampus that facilitates memory (Durakoglugil et al. 2005).

26. One week later, recall of 30 words was increased from 5–10 words to 15–20 words. Intervals of 15 and 45 minutes did not work as well (Powless et al. 2003).

27. Nielson et al. 2005, Nielson and Bryant 2000. This finding is consistent with the behavioral conditioning research of the 1960s (Skinner 1974) and may explain why rewards given on a variable ratio result in more persistent behaviors. If rewards are given on a fixed ratio, then they become expected, no stress hormones are secreted, and there is no extra learning effect.

28. Nielson et al. 1996. Muscle tension-induced arousal can enhance later retention performance, but this effect is attenuated by beta-adrenergic receptor antagonists.

29. The plant sage inhibits the enzyme acetylcholinesterase that breaks it down. Research on recall revealed that drinking sage consistently improves recall (Tildesly et al. 2003). Rosemary aroma has a similar action (Moss and Cook 2003). Gingko biloba seems to have little if any effectiveness.

30. Moss and Cook 2003.

31. Koppelstatter and Rubin 2005.

32. Siegel 2001. Memory of both words and faces is strengthened during sleep, but through different mechanisms. Overnight retention of verbal memory is highly correlated with the number of sleep spindles detected over the left frontal-central areas of the cortex

during dreaming. However, overnight retention of newly learned faces was found to correlate with non-dream sleep time. It appears that coordinated bursts of electricity in the hippocampus and cortex during sleep foster changes in the synapses of certain cells that bring about long-term memory storage (Clemens et al. 2005). A gene, called zif-268, turns on during dream sleep after heightened brain activity and is associated with strengthened communication between nerve cells (Ribeiro et al. 1999). Acetylcholine levels during sleep should be low.

33. Fenn et al. 2003.

34. Wagner et al. 2004, Walker and Stickgold 2004. For the circadian rhythms see Lyons et al. 2005.

35. Eight hours of sleep may also double the probability of acquiring insights into the solutions of problems (Wagner et al. 2004). The cerebellum, that controls speed and accuracy of skills, is more active during sleep, whereas the limbic system that controls emotions such as stress and anxiety may be less active.

36. The more durable connections based on meaning are considered a "deep" level of processing.

37. Reviewing notes after class each day, or at least before going to bed may help recall. U.S. college students who reviewed their notes within a day recalled about 75 percent of the information. Those who did not review their notes were unable to recall even 50 percent of the information after one day and only a little more than 20 percent of the information after nine weeks (www.ucc.vt.edu/lynch/SSForgetting.htm).

Chapter 5

1. See, for example, Menges 2003. For example, in Francophone Guinea, only one out of 10 students knew the entire alphabet by the end of grade 2, and on average, students could read 4 of the 20 words presented. Only 7 percent of students at the end of grade 2 were able to identify 15 or more of the most frequently used words in their readers or story books (Spratt and Tamba 2005). Bender 2005 reports similar results in the Francophone schools of Mali. Only 25 percent of children in grade 1 and 45 percent of grade 2 children sampled in Peru were able to read a single word (Abadzi et al. 2005), and only about 40 percent of younger Indian students were fluent (Pratham Learning Survey; found at vidyarambam.org/programmes/remedials.asp, www.indianngos.com/p/pratham/).

2. OECD-CERI 2003a. Research in this respect is evolving, but it suggests that visual and rhythmic stimulation could improve reading and attention.

3. Reading requires sufficient white matter present in the left temporal lobe (Nagy et al. 2004).

4. Passolunghi et al. 1999.

5. If nothing else enters the working memory, the trace may stay 20 seconds or so. But the 12-second period seems to be the most important aspect for reading, with the number of words varying according to length. Also sentences with simpler grammar are probably deciphered more rapidly, so the estimate is rough.

6. Barr et al. 2002, p. 253. Research with Turkish children shows a similar drop in comprehension as errors increase; for example 87 percent accuracy among second graders has been associated with comprehension scores of 71 percent, while 71 percent accuracy has been associated with comprehension scores of only 37 percent (Aydin Durgunoglou, personal communication, September 30, 2005). However, speed and accuracy are correlated very highly, often about 0.95 (Marilyn Jager Adams, personal communication, June 2005).

7. Shaywitz 2003, pp. 76-87.

8. The brain recognizes letters (as well as faces) by parts, not as wholes. Our visual system recognizes "bite-sized pieces" of our world, and our brains assemble them into the perceptual objects that constitute our environment. This may be one reason why the phonics-oriented methods are more effective than "whole language" (Martelli et al. 2005).

9. Because automatic processes show low metabolic activity in the brain, there is an inverted U relationship as students learn to read. Initially the occipito-temporal lobe shows little activity and then becomes much more active; among proficient readers, activity then decreases (OECD-CERI 2000, p. 51).

10. People seem able to estimate accurately which letter combinations occur more and less often in languages they do not know well. This ability facilitates automaticity and rapid prediction.

11. The "word superiority effect" facilitates recognition of individual letters within a letter group that conforms with spelling rules and is thus identified as a word. See Abadzi 2003a for a review.

12. August et al. (in press) for Spanish, Ledesma and Morris 2005 for Tagalog, Cummins et al. 1984.

13. Wimmer et al. 1999.

14. Cossu 1999; Harris and Hatano 1999, p. 17; Seymour et al. 2003.

15. Hagtvet et al. 2005, Hagtvet and Lyster 1998, 2003.

16. Wimmer et al. 1999.

17. Seymour et al. 2003.

18. Barr et al. 2002, p. 76. New speed norms for English (Hasbrouck and Tindal 2006) show the 50th percentile as 53 words per minute (spring of grade 1) and 89 words per minute (spring of grade 2); 60 words per minute corresponds to the 25th percentile in the spring of grade 2.

19. Red Maestros de Maestros, Web site accessed in 2005: www.rmm.cl/index_sub.php?id_contenido=1128&id_seccion=310&id_portal=75.

20. In 2005 the Web site was: www.educandojuntos.cl/.

21. Pérez Villar 1996.

22. Equipo de Orientación Educativa de Marbella 2003.

23. de la Colina et al. 2001.

24. Seymour et al. 2003.

25. Laberge and Samuels in 1974 found that speed was a prerequisite for comprehension. Breznitz 1997a and 1997b reached similar conclusions. The comparative merits of teaching fluency versus discussion of word meanings were tested with struggling primary-school readers; it was found students who had learned to recognize the words to the point of automaticity answered more comprehension questions than students who merely were

instructed on individual word meanings (Tan and Nicholson 1997). This is why fluency is now considered a prerequisite for comprehension (Snow et al. 1998; Pikulski and Chard 2005).

26. Cossu 1999, Goswami 1999.

27. Duncan and Seymour 2000. Longitudinal studies consistently find that children need to know 80 percent or more of the letter-sounds before word reading and decoding can take off (Dr. Philip Seymour, personal communication, November 2005).

28. The maternal language to some extent determines which phonemes are salient in children's minds, and some are more so than others. For example, Czech children can manipulate the prevalent onset phonemes better than the codas and the intermediate vowels. Furthermore, some languages have a phonemic structure easier to access than others, and English is rather difficult in this respect (Marketa Caravolas, private communication, September 30, 2005). Some argue that the benefits of phonological awareness for reading are clear in the case of English, but less clear for languages with simple spelling rules, such as German or Italian (Goswami 1999). However, it was found that four one-hour sessions of word games in Israel significantly increased children's performance (Bentin and Leshem 1993).

29. As IEG missions have observed, students who read the material laboriously may reply to comprehension questions by rereading aloud a few words in the middle of the text.

30. One study comparing temporal plane asymmetry, an indicator of dyslexia, found no difference in incidence between low- and higher-income children in the United States (Eckert et al. 2001).

31. Retarded Italian children aged 11 with a mean IQ of 44 could read 93 percent of words correctly (Cossu 1999). Correlations between reading and IQ are 0.30–0.40, so only 10–15 percent of the variation in reading ability depends on students' general intellectual ability (Siegel, 1992; Stanovich, 1991).

32. Rumsey et al. 1997, Paulesu et al. 1996.

33. People with dyslexia may be unable to filter out nonessential information, which then interferes with decoding (Sperling et al. 2004).

34. Paulesu et al. 2001. French readers have intermediate-level difficulties. Poor readers often have problems with sounding out letters and slow speed. Besides the occipito-temporal lobe, some other neurological factors influence reading performance. Some people have overall faster nerve conductivity and will name words faster. Even if they have a difficulty sounding out letters, they may overcome it with speed. But if children have both a phonological and a fluency deficit, they have a hard time learning to read well. In a simple orthography, dyslexia appears to be a matter of speed more than of accuracy, while accuracy problems are abundant in English (OECD-CERI 2003a).

35. Shaywitz 2003. Perhaps it is possible to teach adults or children learning to read (particularly those who have reading difficulties) to visualize letters while repeating the sound or look at them with concentration for several seconds. Other effective interventions to improve reading include a Japanese videogame (Dance Dance Revolution) that involves matching movements to visual and rhythmic auditory cues. The game seems to strengthen nerve networks involved in reading and attention and thereby improve student outcomes (McGraw et al. 2005; aaroninjapan.com/ddrvideos.html).

36. Abadzi et al. 2005.

37. Adams 2005. In industrialized countries, interactive computer programs and toys to give children reading feedback have been developed. Unfortunately cost and limited computer availability limit their utility in low-income countries.

38. de la Colina et al. 2001, Banerji et al. 2004.

39. Hartley and Swanson 1986. Neuropsychological studies show that most change in children's brains happens during the first three years of schooling. Illiterates mature later with respect to neuropsychological features, possibly as a result of later working memory maturation (Ardila et al. 2000b, Ostrosky et al. 1998).

40. Rayner et al. 2001, National Reading Panel recommendations (National Institute of Child Health and Human Development).

41. Phonological processing is also very relevant in Chinese, and the proportion of dyslexic children in mainland China is about 4.55 percent to 7.96 percent. (Zhang, et al. 1996, cited in OECD-CERI 2002). Chinese children start by learning a syllabic alphabet, which is gradually replaced by ideograms. One problem with the Chinese script is that the number of characters is too large, and not all can be automatized. Students and even adults may forget some over time (if for example they live abroad) and thus become unable to read parts of a message.

42. Smith 1983, Goodman 1986.

43. Dahl, Lawson, and Grogan 1999.

44. Tunmer et al. 2003, Nicholson 1999.

45. Stahl et al. 1994.

46. Children with high initial vocabulary scores had better reading scores with more implicit and independent teaching (Connor et al. 2004).

47. Stahl and Miller 1989 looked at five projects conducted as part of a U.S. Office of Education study of first grade reading programs and at 46 additional studies that appeared as dissertations, transcripts of lectures, or journals, with sufficient data to permit a metastatistical analysis. (More information can be found at www.ldonline.org/ld_indepth/reading/whole_language_lives_on.html).

48. British studies include Watson and Johnston 1998, Solity at al. 1989, Deavers et al. 2000, and Landerl 2000. Examples of European research on the advantages of phonics over alternative approaches in English include Hutzler et al. 2002, who found a 10 percent advantage of phonics in English through a computer simulation of connectionist networks.

49. Tunmer et al. 2003, Denton and Mathes 2003.

50. Ehri et al. 2001a, 2001b; Johston and Watson 2005.

51. National Institute of Child Health and Human Development 2000 (www.nichd.nih.gov/publications/nrp/findings.htm).

52. Writing develops differently from reading (Cossu 1999). Countries teaching through phonics (for example, in Cuba) tend to emphasize reading first, with the expectation that students will write more easily once they know basic decoding. However U.S. and Latin American educators emphasize "primitive writing" as a means to learning reading (Ehri 1987, 1995; Ferreiro et al. 2004). This method may help with English but its value in phonetically simple languages is unclear. At the very least it is time consuming.

53. See OED 2005c for a review.

54. Administración Nacional de Educación Pública 2002.

55. Borstrom et al. 1999.

56. The sound of many combination symbols is obvious from their parts (as in the Devanagari script), but some may not be as obvious or may be pronounced differently (as in Bengali). Syllable symbols of south Indian languages in particular may be visually confusing. Research in south India showed that most children in grades 2 and 3 had mastered 40 percent or fewer of the symbols tested. Proficient Tamil readers in grade 2 had mastered only 60–80 percent of the symbols (Nag-Arulmani 2003).

Chapter 6

1. Learning a second language increases the density of gray matter in the left inferior parietal cortex, and the degree of structural reorganization in this region is modulated by the proficiency attained and the age at acquisition (Mechelli et al. 2004).

2. Johnson and Newport 1989, Johnson and Newport 1991.

3. Mervis and Bertrand 1994. Babies at 10 months can learn two words in five minutes with just five presentations of a word and an object (Pruden et al. 2006). Children ages 2–8 are able to remember words they heard once two weeks earlier through a process called fastmapping. This ability enables them to infer a connection between a new word and referent, to comprehend a new word after a single exposure, and to recall some nonlinguistic information associated with the referent (Dollaghan 1987). Babies will attach the label to the object that interests them. Generally, children learn words best when they already have the object in mind. When an adult supplies a label after rather than before a child has looked at an object, the child comprehends the label more accurately (Dunham et al. 1993; Tomasello 1988, 1992, cited in Bukatko and Daehler, p. 237). Compared to children, adolescents make faster initial progress than adults when learning a new language, but their ultimate attainment is not as high (Hoff-Ginsberg 1997).

4. Collier 1988, 1989; Reich 1986. European studies from the 1960s and 1970s, when instruction emphasized grammar, showed older students consistently performing better. For example, British children who had begun French instruction at age 11 performed better on tests of second language proficiency than children who had begun at 8 years of age (Stern, Burstall, and Harley 1975). Similar results have been found in studies of Swedish children learning English (Gorosch and Axelsson 1964), Swiss children learning French (Buehler 1972), and Danish children learning English (Florander and Jansen 1968). Citations are in McLaughlin 1992.

5. Anglin 1993.

6. Kosonen 2005.

7. Koda 1992.

8. Hakuta 1986, Cummins 1976, Sternberg and Ben-Zeev, pp. 223–224, Ganschow et al. 1998.

9. Additive bilingualism happens when learning a second language does not interfere with the learning of a first language, and both languages are developed. Subtractive bilingualism happens when learning a second language interferes with the learning of a first language. The second language replaces the first language. This is commonly found in children who emigrate to a foreign country when they are young, or orphans who are

deprived of their first language input (Cummins 1991). One reason may be the immaturity of the hippocampus among young children that somehow interacts with poverty effects.

10. Children in western Europe at age 7 and in grade 1 had an increased capacity for phonological analysis at the phoneme level, but not syllabic analysis, rapid naming, and memory span. The development of verbal memory spanning from kindergarten to grade 2 is more modest than the development of phonological processing and naming abilities (Korkman et al. 1999 for a review, also Korkman et al. 2001). This implies difficulties in tasks such as recalling a picture that has been named. Also, the phonological loop of the working memory is the gateway to new vocabulary, and children with a small loop will not easily acquire new vocabulary (OECD-CERI 2002, p. 51).

11. Nation and Waring 1997.

12. Putnam 1975, p. 141. Merely hearing a language is probably insufficient input for the operation of a language acquisition device at any age. The data that matter the most are those that the learner is actively involved with rather than the total amount of a language heard. A child consistently interacting with a relative in a certain language is likely to acquire fluency, even if that language is a small percentage of the amount of speech a child hears daily.

13. Observations were carried out during an IEG mission in March–April 2002.

14. Ideally, instruction in a mother tongue should be used not merely to transition into a foreign language but also to learn the mother tongue.

15. A corollary of the reading research and experience with Koranic schools is that the language matters less than the orthography. Perhaps children will learn how to read more easily in a phonetically spelled language they know very little rather than tackle English or French. Given that many Africans know area languages, it may be more efficient to use textbooks of a neighboring language, if available, to teach basic literacy before proceeding in the lingua franca. However, politics may make this solution impractical even if it is shown to be effective.

16. See Abadzi 2003b for a review, pp. 34–41. Researchers such as Hoover (1982) noted the increased facility that experienced readers bring from one language to another, even when scripts differ.

17. For example, nearly all the minority textbooks of Nepal have been written in the widely used Devanagari script, including Newari, which traditionally used a somewhat different script. Only the Limbu language kept a different script. Although students can become fluent in both, the poor may be at risk of dropping out before learning Devanagari well and thus remaining illiterate in the official script. (Curriculum Development Center.2000; textbooks in Tharu, Tamang, Bhojpuri, Newari, Avadhi, Maithili, and Limbu languages).

18. OED 2005a, 2003b.

19. Slavin and Cheung 2003, research of the Success for All Foundation.

20. Thomas and Collier 1997. School Effectiveness for Language Minority Students (www.ncela.gwu.edu/pubs/resource/effectiveness/thomas-collier97.pdf).

21. Bender 2005.

22. The program was supported by DFID (DFID 2005).

23. Halaoui 2003.

Chapter 7

1. Devlin 2005. Newport et al. 2004.

2. Dehaene et al. 2006.

3. The number system of a language seems to affect thinking, and people may have difficulty calculating without a sufficient number system. The effect was shown by a study of an Amazon tribe that has only names for the numbers small children can track—that is, "roughly one," "two," and "many" (Gordon 2004). Many ancient languages (for example, Sanskrit, Greek, Latin, and Hebrew) had a special conjugation for two objects. Perhaps its gradual extinction from modern languages reflects the improved understanding of larger number sets.

4. OECD-CERI 2002, p. 21.

5. When seeing a visual digit, for example, "3," the fusiform gyrus is active. When hearing or reading the number as a word, "three," the perisylvian area is active. When understanding a number as a quantity—that is, "a lot" versus "a few," "3 is bigger than 1"—the intraparietal sulci are recruited. Thus the brain hemispheres work together rather than separately. However, brain injury or any kind of insult that leads to disorganized brain networks can produce an inability to calculate (a disorder known as acalculia or dyscalculia) in which the brain areas detailed above will not be recruited normally. Specifically, children and adults with this disorder cannot understand the quantity meaning of numbers. For example, they would not be able to perform calculations as simple as "3 minus 1" or to understand what number is between 2 and 4. In other words, they have lost the spatial concept of quantity (Dehaene 1997).

6. Children born preterm and with low birthweight in the West often have numeracy problems. A neuroimaging study has found an area in the left parietal lobe where children without a deficit in calculation ability have more grey matter than those with the deficit (Isaaks et al. 2001). This analogy may hold for some low-income children.

7. Sternberg and Ben Zeev, p. 350.

8. OECD-CERI 2002, p. 33.

9. The Rightstart program developed by Griffin, Case, and Siegler (cited in Sternberg and Ben Zeev 1994, p. 350) teaches basic arithmetical skills like counting, correspondence between number and quantity, and the concept of the number line. This program teaches children a spatial analogue of numbers using physical objects like the game of "Snakes and Ladders." This type of training has been successful in remediating children who have trouble calculating to such an extent that after going through 40 sessions of 20 minutes each, some children started to bypass normally developing children in mathematics class (Dehaene 1997).

10. Vaid and Menon 2000.

11. Michaelowa 2001.

12. Adetula 1990.

Chapter 8

1. Classroom observation is a challenging function requiring training and constant attention. Observation instruments must capture events that are significantly related to subsequent learning, encode them reliably and quickly as they happen, relate them to norms of efficient teaching, summarize them quantitatively, and present them in forms amenable to statistical analyses. One prominent instrument is the research-based Stallings Classroom Snapshot that encodes the amount of time productively used in activities such as reading, lecturing, discussion, copying, seatwork, or kinesthetics. For greater insight and more advanced classes, the Stallings Five-Minute Interaction tracks how classroom activities help elaborate information and link to previous knowledge. It records who initiates an interaction, to whom it is directed, the importance of interaction, and type: instruction, question, response, feedback, and management. "Instruction" can be lecture, "chalk and talk," using examples from life, explaining using material, probe, directives, and cues. "Questions" are coded on whether they invite recall, opinions, and redirection to other concepts. Student responses are coded as group or individual responses, and furthermore as recitations, extended responses, "don't know,"and statements. Teacher feedback consists of acknowledging positively or negatively, punishment, repeating answer, giving answer, and silence or criticism. Another means of observation has been video studies of entire class sessions (Stigler and Hiebert 1999).

2. Global Monitoring Report 2005. After being engaged in a lengthy lecture, children could be asked to get up and do some calisthenics, such as touching their toes. However, physical education is an increasingly smaller part of curricula. Kinesthetic activities were observed during IEG missions less than 1 percent of the time.

3. Tietjen et al. 2004.

4. Stallings 1980, Fuller et al. 1999, Glewwe et al. 1995.

5. Carnoy, Gove, and Marshall 2004. The authors rated the cognitive demand level of classroom activities.

6. Chacko 1999.

7. Glewwe et al. 1995.

8. See, for example, Lockheed and Harris 2005.

9. Carnoy, Gove, and Marshall 2004.

10. Connor et al. 2004. As children's reading scores improve, they may also get more benefit from independent seatwork and implicit teaching.

11. In the TIMSS 1999 eighth-grade math video study, seatwork accounted for about 40 percent of class time. But in the United States, seatwork consisted of 96 percent practice, 3.5 percent application, and 0.7 percent inventive thinking. In Japan seatwork time consisted of 41 percent practice, 15 percent application, and 44 percent thinking (Sigler and Hiebert 1999, p. 71).

12. Fuller et al. 1999, Christian et al. 2000.

13. Glewwe et al. 1995, Stallings 1980.

14. Carnoy, Gove, and Marshall 2004.

15. Higgins and Turnure 1984.

16. Brain imaging research found large differences in the brain activity patterns of participants who were either reading or listening to identical sentences that influenced comprehension. During listening, there was more activation of verbal working memory than during reading Thus, there is more semantic processing and working memory storage in listening comprehension, which might make material that is heard more easier to process than material that is read (Michael et al. 2001).

17. Stigler and Hiebert 1999.

18. Lockheed and Harris 2005.

19. Carnoy, Marshall, and Socias 2004. Japanese students who scored high on the test did work in groups but first they attempted to solve problems by themselves.

20. Fuller et al. 1999.

21. Stallings 1980.

22. Rowan et al. 2002.

23. Christian et al. 2000, Canady and Hotchkiss 1985.

24. McManus 1994, Abadzi et al. 2005.

25. Development Cooperation Ireland 2004.

26. Christian et al. 2000.

27. Stallings 1980.

28. Stallings 1980; also personal communication during World Bank workshops and research, 2004–05.

Chapter 9

1. For example, in Tajikistan "active learning" was piloted through a Learning and Innovations Loan financed by the World Bank, but documents do not clarify what activities constitute "active learning" (World Bank 2003).

2. Piaget 1973, Vygotsky 1978, Daiute 1989, Garvey 1977, and Herron and Sutton-Smith 1971.

3. Bideaud 2001, Brossard 2001, Ducret 2001, von Glasersfeld 2001, Kato and Kamii 2001, de Macedo 2001, and Weil-Barais 2001 (articles in a special issue of UNESCO Prospects). Also see Forman and Pufall, 1988, and Newman et al. 1989.

4. Brooks and Brooks 1993, p. 17.

5. See, for example, von Glassersfeld 2001. The author believes that constructivist instruction saves time in more advanced classes because students already know how to synthesize knowledge.

6. Pinker 1997, p. 342. Human knowledge is cumulative, and schools ensure that innovations are passed on efficiently and without slippage (Tomasello 1999).

7. The 2005 Global Monitoring Report recognized that discovery-oriented methods have a limited utility.

8. Klahr and Nigam 2004.

9. Rosenshine and Stevens 1984.

10. See www.funnix.com.

11. Adams and Engelmann 1996. The *Journal of Education for Students Placed at Risk* 7 (2) 2002 reported a number of studies with positive effects. For example, primary students in 20 Direct Instruction elementary schools in Houston made significantly greater gains in reading than students in 20 control schools (Carlson and Francis 2002). The differences were particularly pronounced in kindergarten and grade 1. Students who had spent more years in the program outperformed children with less program exposure, and students with teachers who demonstrated greater use of Direct Instruction techniques outperformed other students.

12. Kemper and Stringfield 2003.

13. Ryder et al. 2003.

14. Ryder et al. 2003, citing Stahl 1998.

Chapter 10

1. Kim 1999.

2. OED 2004a.

3. Tietjen et al. 2004.

4. Watkins 1999.

5. Barrier et al.1998, pp. 25, 74–75.

6. Linden 2001.

7. Alcazar et al. 2004. Poor results were also obtained in Madhyapradesh, India (Rao and Narasimha 1999).

8. EARC 2003.

9. El Hachem 1998.

10. PROBE 1999.

11. Chaudhury et al. 2004a.

12. Das et al. 2005.

13. Chauhdhury et al. 2004b.

14. Fuller et al.1999, Marshall 2003.

15. Marshall 2003.

16. Wolfe and Behrman 1984, Buchman and Hannum 2001, Jamison and Lockheed 1987.

17. Marshall 2003.

18. World Bank 1996.

19. OED 2003a.

20. Stallings 1975, 1980; Stallings et al. 1979.

21. Kelly 2003. In OECD countries there is considerable variability across teachers and subject areas. Kindergarten teachers were found to have spent most time in noninstructional activities (like transition between activities and management), with much less time spent on mathematics and very little time on science or social studies. Grade 1 teachers devoted considerable time to language arts, but noninstructional time was still high and comparatively little time was spent on math.

22. Abadzi et al. 2005.

23. Tietjen et al. 2004.

24. Considering 75 percent of school days fully or partly in operation, 20 percent teacher absenteeism, and about 25 percent use of class time engaged in learning.

25. In some countries, teachers may not work the number of hours that governments specify because schools schedule them for fewer hours. (Junior secondary education teachers in Indonesia, for example, may only be scheduled to work for 15–18 hours rather than 25.) Sometimes this is due to limitations in the subjects they can teach, but the result is considerable budgetary wastage. Reasons need to be better understood.

26. OED 2003.

27. Hanushek and Kim 1995; Hanushek 1996.

28. Karweit 1985, Millot 1994, Quartarola 1984.

Chapter 11

1. Heyneman et al. 1978 found that textbooks had a positive effect on academic achievement in 15 of 18 studies, and the effect was greater on students from poor backgrounds. Fuller (1986) reported significant effects of textbooks in 14 of 22 studies. Fuller and Clarke (1994) found significant effects in 19 of 26 studies. Lockheed and Hanushek (1988) summarized four studies of textbooks in developing countries; they reported that textbooks improved test scores by 0.34, 0.36, 0.30, and 0.06 standard deviations of individual test scores.

2. In a Nicaraguan study, 48 grade 1 classrooms received radio mathematics education, 20 classrooms received mathematics workbooks, and 20 classrooms served as controls. After one year, pupils who received workbooks scored one-third of a standard deviation higher than the control group, while those who received radio education scored more than one standard deviation higher than the control group. Both differences were significant, and provision of textbooks narrowed gaps between rural and urban students (Jamison et al. 1981).

3. OED 2004c, p. 53.

4. Barrier et al. 1998.

5. Stanovich 1999.

6. Test scores between these two treatments showed almost no difference in the first year and a difference of 0.40 standard deviation in the second. Students from poor families benefited the most (Heyneman et al. 1984.)

7. Glewwe et al. 2001.

8. Okyere 1997.

9. Glewwe et al. 2004.

10. Research on U.S. college students showed that the amount they read predicted individual differences in knowledge of various domains, after controlling for fluid intelligence (Stanovich and Cunningham 1993).

Chapter 12

1. Skinner 1974.

2. Mendl 1999, Welford 1974. The inverted U function demonstrating the optimal amount of stress is called the Yerkes-Dodson law.

3. Medical students before an exam did less well on tests that required them to consider many possibilities in order to come up with a reasonable answer; a week after the exam, they demonstrated less recall but better problem-solving (Alexander and Beversdorf 2004).

4. Effortful control has been assessed with Stroop-like tasks, where a person reacts to stimuli involving automaticity. These tend to activate a very specific region of the brain situated on the frontal midline called the anterior cingulated cortex, situated just behind the orbito-frontal cortex. This area seems to play a critical role in the brain networks responsible for detecting errors and regulating cognitive processes as well as emotions to achieve voluntary control of behavior (OECD-CERI p. 59).

5. Four-year-old children left alone in an otherwise empty room were faced with the task of resisting eating one marshmallow displayed before them in order to get two marshmallows later upon return of the experimenter. The delay of time during which the child succeeded in resisting the impulse to eat the first marshmallow turned out to be significantly correlated with the achievement of later academic success, as measured by the ability to deal with frustration and stress, task perseverance, and concentration. In addition, the group of students who exhibited a longer delay of gratification as preschoolers eventually showed much higher achievement in the U.S. Scholastic Aptitude Test (OECD-CERI 2003b).

6. Also violence often inhibits consolidation (Dr. Kristy Nielson, Marquette University, personal communication, May 16, 2005); Delaney-Black et al. 2002, Meyer et al. 1993.

7. Lloyd and Mensch 1999, UNICEF 2002, cited in Birdsall et al. 2004.

8. Fuller 1987, Fuller and Clark 1994, Scheerens 2000.

9. Barrier et al. 1998.

10. Michaelowa 2001.

11. LeTendre et al. 2005.

12. One empirical guideline for homework in the United States is the "ten minute rule," which suggests that the amount of homework should be 10 minutes multiplied by the grade level of the student (Armistead et al. 2001, p. 37).

13. Brown et al. 2002.

14. Spiral curricula present the same topic in various grades at increasing level of detail (John Geake, personal communication, April 9, 2006).

15. Ho et al. 2003.

16. In 1993 it was shown that college students who listened to Mozart's Sonata for Two Pianos in D Major for 10 minutes performed better on a spatial reasoning test than students who listened to new age music or to nothing at all (Rauscher et al. 1993). It was shown stimulation with the above sonata has measurable neurochemical effects. Rats that heard a Mozart sonata had increased gene expression of a neural growth factor, a compound involved in learning and memory, and a synaptic growth protein in their hippocampus, as compared to control rats that had listened to equivalent amounts of white noise (Rauscher and Hong 2004.) The Mozart effect may be due to musical sequences that tend to repeat every 20–30 seconds, which is about the same length of time as brain-wave patterns and other functions of the nervous system (Bell and Mason 2006).

17. Schellenberg 2004.

18. Ho et al. 2003.

19. International assessments of student achievement are conducted via MLA (UNESCO), SACMEQ (southern Africa), PASEC (francophone Africa), and OREALC, PISA, TIMSS, PIRLS, UIS (see acronyms in introduction). PASEC scores have a minimum threshold of 40 percent correct items for acquisition of basic skills, while response at chance level is almost 30 percent (Michaelowa 2001).

20. Since students often cannot read well and are unfamiliar with multiple-choice tests, reliability issues arise. An experiment with Tanzanian 13-year olds showed that low scores improved significantly after one hour of instruction, and the greater improvements were made by students who had not scored the highest on pretest scores (Grigorenko and Sternberg 2000, cited in Sternberg and Ben-Zeev 2001, p. 314).

21. Brief oral "1-minute reads" are used in Canada and the United States, such as the Dynamic Inventory of Basic Early Literacy Skills. A number of reading researchers also use timed measures of word recognition. See Hasbrouck and Tindal 2006 for an update.

22. Cotlear and Crouch 2006.

23. Roediger and Karpicke 2006.

24. Lehman et al. 2004.

25. Michaelowa 2001.

26. www.cefpi.org. Interviews by an IEG mission on lower-secondary education in 2006 documented the desirability of appealing project-financed buildings, compared to dilapidated nearby schools. Some posted a sign stating that they could not admit more students.

27. OED 2004c.

28. Global Monitoring Report 2005.

29. Heschong Mahone 1999; www.cefpi.org.

30. Hathaway 1994.

31. Hedge 2004.

32. Harner 1974.

33. www.cefpi.org.

34. Higgins and Turnure 1984.

35. Wingfield and Byrnes 1981.

Chapter 13

1. ActionAid International 2005.

2. Global Monitoring Report 2005.

3. Lockheed and Verspoor 1991.

4. For example, the Danish portion of the 2000 PISA report shows significant relationships between math performance and class size. The optimal size seems to be 16–19 students, if numbers are higher or lower performance drops. These findings persisted when factors related to socioeconomic background were controlled for (OECD 2003, p. 3).

5. West and Woessmann 2003.

6. For example, Blatchford 2003; a study in rural Honduras (Bedi and Marshall 1999). Finn et al. 2005 found in that attending small classes for the three or more years in grades K-

3 increased the likelihood of graduating from high school, especially among low-income students in the United States.

7. Biddle and Berliner 2002a, 2002b.

8. Carnoy, Gove, and Marshall 2004.

9. Kremer et al. 1997.

10. Michaelowa 2001.

11. Birdsall et al. 2004.

12. OED 2005a, 2005b.

13. Berns et al. 2001. During the mutually cooperative social interactions in games of the "prisoner's dilemma," activation was noted in the brain areas linked to reward processing, such as the nucleus accumbens, the caudate nucleus, ventromedial frontal/orbitofrontal cortex, and rostral anterior cingulate cortex (Rilling et al. 2002).

14. The way that the mind forms categories may account for this exaggerated perception of in-group members as homogeneous and out-group members as different (Quattrone and Jones 1980, Doise 1976).

15. Rabbie and Horwitz 1969, Horwitz and Rabbie 1982.

16. Group work might be an indication that students have limited attention or self-control and cannot do the work alone. It is used less in some of the higher-performing school systems (for example, Cuba) or in private schools of Chile (Carnoy, Gove, and Marshall 2004).

17. Johnson et al. 1981, Rysavy and Sales 1991.

18. Rysavy and Sales 1991.

19. Johnson et al. 1981.

20. Terwel et al. 2001.

21. Mitra and Rana 2001.

22. Tudge et al. 1996.

23. Fuchs et al. 2000.

24. For example, Latané et al. 1979. Perhaps students sitting at the back of classes are less involved because of the "social loafing" phenomenon.

25. Petty et al. 1980.

26. Eraut 1995, Stephenson 1994, Box and Little 2003, and Aronson et al. 1978.

27. Meta-analysis reported in Gillies 2004 and conducted by Lou et al. 1996.

28. Kurzban and Houser 2005.

29. McNeese 2000.

30. Aronson et al. 1978, Aronson and Patnoe 1997, Box and Little 2003, Walker and Crogan 1998.

31. Borsch et al. 2002.

32. Gillies 2004, 2003; Gillies and Ashman 1998; Terwel, et al. 2001; Webb and Farivar 1994.

33. See, for example, Webb and Palincsar 1996, Baker et al. 2004.

34. Dugger 2004 citing an evaluation carried out by the Poverty Action Lab at the Massachusetts Institute of Technology (MIT).

35. Finder 2005. Other U.S. areas to adopt economic integration plans include La Crosse, Wisconsin; St. Lucie County, Florida; San Francisco; Cambridge, Massachusetts; and Charlotte-Mecklenburg, North Carolina.

36. Rowley and Nielsen 1997, Psacharopoulos, et al. 1993.

37. Gutierrez and Slavin 1992.

38. Much of this information has been disseminated in UNESCO-led online discussions and conferences with the staff of the Escuela Nueva Foundation in Colombia. (Presentations and curriculum development techniques by Dr. Pat Pridmore, Institute of Education, University of London.)

39. Mingat and Rakotomalala 2004.

Chapter 14

1. Pervin 1983.

2. Pratt 1936. Reward-related brain regions “alert” in advance the learning regions to promote memory formation (Adcock et al. 2006).

3. Deci and Ryan 1985, 1992, 2000.

4. Novelty is pleasing and a positive reinforcer. The nucleus accumbens (a part of the basal ganglia) is the primary structure responsible for this connection; it gets input from the amygdala, which is probably the main reason why the amygdala is responsible for stimulus-reinforcement association learning (Rolls 1999).

5. Wrzensnieski et al. 1997, 2001.

6. Eisenberger and Rhoades 2001, Henderlong and Lepper 2002.

7. This is sometimes called the Premack principle (Premack and Premack 2003).

8. Bolles 1975, McClelland 1975, Skinner 1953.

9. Jenkins et al. 1999.

10. Deci and Ryan 1991.

11. This finding is referred to as the over-justification effect (Deci 1991, Harlow et al. 1950, Tang and Hall 1995).

12. In real terms, teachers’ wages have declined over time relative to average incomes in low-income countries; in Africa, teacher earnings were lower in real terms in 2000 than they were in 1970. In 1998–2001, there were significant salary reductions in Argentina, Indonesia, the Philippines, Tunisia, and Uruguay. Teacher earnings are often too low to provide an acceptable standard of living; for example, teachers earn less than US$2 a day in Sierra Leone government schools, but even less in community schools (Global Monitoring Report 2005).

13. The strongest predictors of salary satisfaction were employment status (with civil servants having higher satisfaction) and proximity of educational/cultural amenities (Rogers and Dang 2005).

14. Chaudhury et al. 2004.

15. An evaluation of a performance-based pay bonus for teachers in Israel concluded that the incentive led to increases in student achievement, primarily through changes in teaching

methods, after-school teaching, and teachers' increased responsiveness to students' needs. (Lavy 2004 cited in Vegas and Umansky 2005).

16. Vegas and Umansky 2005.

17. Rogers and Dang 2005.

18. Duflo and Hanna 2005.

19. Chaudhury et al. 2004

20. Bandura 1997.

21. Bandura 1986.

22. Bandura and Locke 2003.

23. Scholz et al. 2002.

24. Though public expenditure amounts per student had a positive effect on achievement in this study, salary levels related to the per capita GDP were not clearly related to achievement (Michaelowa 2001).

25. Atkinson 1974, 1981, 1992; Atkinson and Birch 1978.

26. This feature is evident in the tendency of the prefrontal cortex to maintain memories ready to use and lists of things to do (Fuji and Graybiel 2003).

27. Weldon and Yun 2000.

28. Koestner et al. 2002, Koole and Spijker 2000.

29. Truskie 1982.

30. Conte and Jacobs 1997.

31. Schnake and Cochran 1985.

32. Lindkvist and Llewellyn 2003.

33. Tetlock and Boettger 1989, Weldon and Gargano 1988, Tetlock et al. 1989.

34. Harnkness et al. 1985.

35. Darling-Hammond 1986.

36. Pang 2003.

37. See, for example, Development Council of Ireland 2004.

38. Chaudhury et al. 2004; Michaelowa 2001.

39. In China, successful administrators may involve a teacher's family to increase social pressure and encourage the teacher to change or to leave the profession (Schaffer et al. 2002).

40. For example see Tietjen et al. 2004, Duflo and Hanna 2005.

41. Downey et al. 2004.

42. Marshall 2004, Michaelowa 2001, Chaudhury et al. 2004.

43. Vegas and Umansky 2005.

Chapter 15

1. Vegas and Umansky 2005.

2. People usually show community solidarity by contrasting their attitudes with those of people who are members of outgroups and deemed to deserve less help (Hoffman 1990). U.S. research suggests that likelihood of help depends on the race of the victim (Gaertner et al. 1993).

3. See, for example, findings by Lockheed and Harris 2005.

4. In Ghana 19 percent of households paid school authorities to get their child into primary school, and in Pakistan, 92 percent reported having to pay bribes averaging US$86. Transparency International studies for Belarus, Slovakia, and Georgia detail the nature of abuses surrounding the market for school acceptance, grades, and graduation at all levels of the school system. (Transparency International 2001, 2004; www.transparency.org) These practices filter down into the earlier years as well, but often in less insidious forms.

5. Punishment can give pleasure to teachers, as studies have shown of the dorsal striatum in the brain (de Quervain et al. 2004; Annex part II). Harassment by male teachers may be one reason why some studies show that girls are more likely to enroll and less likely to drop out when they have female teachers (for example, Michaelowa 2001).

6. Teacher requirements may be one reason why the proportion of primary students receiving private tutoring can be quite high—for example, an estimated 45 percent in Hong Kong, 39 percent in Delhi, 69 percent in Kenya, and 73 percent in Korea (Bray 2003, cited in Birdsall et al. 2004).

7. Michaelowa 2001.

8. Global Monitoring Report 2005.

9. Abadzi et al. 2005.

10. Tietjen et al. 2004.

11. The HIV/AIDS pandemic is severely undermining the provision of good education and contributing significantly to teacher absenteeism (Global Monitoring Report 2005).

12. See, for example, Marshall 2003.

13. UNESCO 2001. Also, a pilot with U.S. teachers showed that half had math anxiety (Alexander and Martray 1989, cited in OECD-CERI 2003a.). Math anxiety may influence number-fact retrieval as well as complex mental calculation, though not arithmetical reasoning.

14. Chaudhury et al. 2004.

15. Teachers may become burned out when they feel undervalued, denigrated, overworked, unappreciated, or unable to reach students; they may perceive their efforts as not being met with commensurate rewards, satisfaction, or fulfillment. They may see their work as futile and inconsistent with the ideals or goals they had set earlier on (LeCompte and Dworkin 1991, Farber 1998, Bullough and Baughman 1997). Role ambiguity and role conflict are also related to burnout (Wood and McCarthy 2002).

16. Research suggests a quadratic relationship between teaching effectiveness and experience. Initially experience relates positively to test scores, but later the relationship is negative (Michaelowa 2001).

17. Bramald et al. 1995, Zeichner et al. 1987, Zeichner and Klehr 1999, Calderhead and Robson 1991, Knowles 1992, Lortie 1975, Feinman-Nemser 1983.

18. Darling-Hammond 1997, 1998; Stigler and Stevenson 1991; OECD-CERI 1998.

19. Humans are predisposed to learn information consistent with their convictions, and direct attention to information that is consistent with their beliefs. The brain treats information inconsistent with beliefs as error, so such information may be forgotten. Furthermore, people are more likely to believe untrue facts told by people of authority, such as senior educators (Fugelsang and Dunbar 2005).

20. Mirror neurons are located in the frontal lobe adjacent to the motor cortex. They fire when a monkey performs a given task, but also when he sees another monkey perform the same task (Rizzolatti et al. 2002.)

21. Bandura 1977, 1986; Dykeman 1989.

22. Simons, Whitbeck, Conger, and Wu 1991.

23. For example, studies carried out in countries under various donor-financed projects (see OED 2004a, 2004b, 2005a, 2005b, and 2005c for reviews).

24. Kagan 1992, Treagust et al. 1996.

25. Participants may travel significant distances to meet, and teachers must learn from their peers, particularly those with seniority. Camaraderie may result along with closer linkages that may foster pleasant feelings about the profession and accountability.

Chapter 16

1. Nunnally and Bernstein 1994.

2. The normal curve is a graphical interpretation of a population that is "bell shaped," as it has the highest frequency of items in the middle. The standard deviation is a measure of spread within a distribution (the square root of the variance).

3. Michaelowa 2001. Similar conclusions reached by Fuller and Clark 1994, Kraft 2003.

4. The total estimated annual external aid to education required to reach universal primary education of reasonable quality by 2015 has been estimated at US$7 billion (classroom instruction is a fraction of that). In 2005, there was bilateral and multilateral aid to basic education of US$1.5 billion and new pledges could increase aid to US$3.2 billion. However, total resources raised have been tiny in relation to requirements. Even in the first 10 countries endorsed for the Fast-Track Initiative, a financing gap of US$200 million remained in 2005 (Global Monitoring Report 2005).

5. A 1999 study of six African nations exhibits a range of relationships between enrollment and completion rates. Kenya had the lowest completion rate, at 63 percent, but 65 percent of its grade 6 pupils achieved minimum literacy skills—a better outcome than in any other country. Malawi's completion rate of 64 percent was almost identical to Kenya's, yet only 22 percent of its grade 6 pupils could demonstrate minimum literacy skills. And Zimbabwe, with a completion rate of 113 percent, had only 56 percent of its grade 5 pupils attaining minimum literacy skills (Ellis 2003).

6. Mingat 2003.

7. Twenty-eight countries are at high risk of not achieving EFA. This number, which includes countries in sub-Saharan Africa and South Asia, represents 25 percent of the world's population (EFA Global Monitoring Report 2002, p. 16).

8. Ostrosky et al. 1998.

9. A means to sensitize government and donor staff to classroom issues also might be through brief *teaching immersion*, similar to the village immersion experiences the World Bank did in earlier years. Staff might go to villages and stay for a week, helping teachers teach classes (particularly multigrade classes) and tutoring students in the afternoon.

Annex

1. Near-term gains may be found by linking educational theories and practices to cognitive science, not necessarily cognitive neuroscience (Bruer 1997). "Brain-based" learning claims by some marketers of educational materials have sometimes created credibility problems.

2. Crowley and Katz 2000.

3. CERI 2002, p. 61. The brain eliminates unused synapses starting at 11–12.5 years. Gray matter is thinned at 0.7 percent annually until the early 20s.

4. Each neuron thus may have a limited number of permanent neighbors, and any further rewiring through experience is limited to changes in the spines that connect those neurons (Trachtenberg et al. 2002).

5. For a popularized review, see Park 2004.

6. Neurons send messages through electrically-charged chemicals (ions), such as sodium, potassium, and calcium. When a stimulus changes the electric potential below a threshold (about –55 millivolts) a neuron responds with an explosion of electrical activity (the action potential) that is fixed in size for each neuron. If the threshold is not exceeded, the neuron does not fire. Thus, neurons operate on an all-or-none basis. H-channels, distributed throughout the dendrite membrane, allow the passage of potassium and sodium ions into and out of the neuron and are altered within 10 minutes following a learning event (Fan et al. 2005).

7. The N-methyl-D-aspartate (NMDA) receptor opens when it receives two different signals at roughly the same time and triggers "long-term potentiation," which is believed to help increase synaptic connections (Schachter 2001, p. 38). Norepinephrine is involved in retrieval of memories through the hippocampus (Murchison et al. 2004), and the neurotransmitter acetylcholine is important for memory consolidation. The ability to retrieve complete memories on the basis of incomplete sets of cues is related to the activity of this receptor in the hippocampus (Nakazawa et al. 2002).

8. The axon groups form hexagonal modules of 0.5 mm (Calvin 1997). Groups of 80–100 cells form functional units with connected wiring called minicolumns; there are millions of these throughout the brain.

9. There are mechanisms to build "consensus" in nature. Cellular automata are items that are turned either on or off according to whether their neighbors are on or off, much like arrays of light bulbs in store advertisements. Complex behaviors in natural and social sciences can be simulated and modeled through the rules of cellular automata (Wolfram 2002).

10. Evolutionary psychology uses knowledge and principles from evolutionary biology to research the structure of the human mind. The basic premise is that human neural circuits were designed by natural selection to solve problems that our ancestors faced during our species' evolutionary history. Our modern skulls house a stone-age mind, and will learn best if data are presented to match ancient data requirements (Cosmides and Tooby 1992).

11. When the brain becomes active, blood flow increases. Researchers use the scans to evaluate signs of oxygen level in the blood of the brain. Functional magnetic resonance

imaging (fMRI) tracks the magnetic properties of hemoglobin, a protein in red blood cells that carries oxygen to body tissues. The equipment detects the magnetic differences in various parts of the brain while subjects' memory or senses are tested. Other imaging techniques include (i) diffusion tensor imaging, a variation of MRI that tracks water molecules along the myelin sheath and can thus study the connections between different brain areas; (ii) evoked potentials, an older and less elaborate method that monitors brain arousal in response to various stimuli and informs on the temporal characteristics of signal processing (Sekuler and Blake 2001, p. 23); (iii) positron emission tomography (PET), which involves injection of radioactive dyes and can only be given to subjects once a year, and (iv) magnetoencephalography (MEG). The latter, which looks like a big helmet, measures the magnetic flow when neuron groups are energized—for example, after 100, 200, or 300 milliseconds; it records and locates the source of the magnetic field. Its advantage is that data can be interpreted without the need for many comparisons. Scientists can also record the activity of single neurons, offering insight on important details of how the brain works. When the MEG data are superimposed on a magnetic resonance image, another useful technique, magnetic source image (MSI), is created.

12. Fisher and Sloutsky 2005 found that children who did not know how to categorize certain animals remembered more details about them than animals they had categorized. However, the inappropriate use of categories may lead to problems such as stereotypes.

13. The actions of each lobe and hemisphere are somewhat different. Both the frontal and medial temporal regions participate in memory formation of verbal and spatial items; the right frontal cortex becomes active while memorizing nonverbal items, such as a face or a picture of an object. By contrast, the left frontal cortex becomes active while memorizing words and is closely associated with remembering and forgetting. Similarly, the left occipital lobe is more important for letter and word recognition whereas the right occipital lobe is more important for recognition based on fine perceptual discrimination, such as faces (Gazzaniga et al. 2002).

14. Gray et al. 2002. The prefrontal cortex only reaches maturity around the third decade of life. It is important to keep it unfettered from negative emotions in order for optimum learning to take place (OECD-CERI 2004).

15. Rizzolatti et al. 2002.

16. Saddoris et al. 2005.

17. The subcortical region includes parts of the limbic system, such as the cingulated cortex, hippocampus, mamilary bodies, fornix, and amygdala.

18. Slotnick et al. 2002, Fujii et al. 2002.

19. Slotnick et al. 2002.

20. Clemens et al. 2005. Other subcortical structures also play a role in memory, such as the fornix and mamillary bodies that together with connected structures support episodic memory (Parker and Gaffan 1997).

21. As memories age, the networks gradually change. Initially, memories for everyday life events appear to depend on networks in the hippocampus. However, over time, these memories become increasingly dependent upon networks in the region of the brain called the anterior cingulate cortex (Fujii et al. 2002).

22. Schachter 2001, p. 47.

23. Meyer-Lindenberg et al. 2005.

24. Cited in Reisberg are Cahill et al. 1996, Gold 1987, White 1991, van Stegeren et al. 1998.

25. Fear and negative emotions activate the amygdala, causing an immediate shutdown of other parts the brain (inhibiting a large part of the cortex), thus making it hard to learn properly. Watching just 10 minutes of classic horror films or prime-time television comedies can have a significant short-term influence on areas of the brain critical for reasoning, intelligence, and other types of higher cognition. Emotion and cognition are integrated in the lateral prefrontal cortex (Gray et al. 2002). The prefrontal cortex only reaches maturity around the third decade of life. Strong negative emotions can inhibit optimum learning (OECD-CERI 2004).

26. Villarreal et al. 2002. People given a drug that blocks the effects of stress hormones do not remember well the details of an upsetting story at a later time (Cahill et al. 1994).

27. Even undesirable automatic behaviors are hard to modify. For example, smokers have difficulty stopping the unconscious movements of lighting cigarettes, and touch typists find it hard to switch from the QWERTY typing layout created for early typewriters to more efficient systems.

28. See, for example, Ullman et al. 1997. Though much can be learned without an effort or incentive, the learning is probably not demonstrated without a motivated expectation of reward (Tolman and Honzik 1930).

29. Park 2004.

30. Reisberg 2001, p. 27.

31. The cerebellum increases dramatically during adolescence and continues growing until the mid-20s (Park 2004).

32. Rilling et al. 2002, and Berns et al. 2001.

33. The ventral tegmental area is a group of dopamine neurons in the midbrain. The substantia nigra contains neurons whose axons project to the caudate nucleus and putamen parts of the basal ganglia.

34. de Quervain et al. 2004.

35. Rolls 1999.

36. Perez-Gonzalez et al. 2005

37. Newport et al. 2004.

38. Croal 2004.

39. Patterson and Hodge 2000.

40. Gazzaley et al. 2004.

41. Todd and Marois 2004.

42. Engle et al. 1999.

43. Vogel and Machizawa 2004.

44. Gathercole, Pickering, Ambridge, and Wearing 2004; Kail 1997.

45. Boutla et al. 2004.

46. Peterson and Peterson, 1959.

47. Kail 1997.

48. Ostrosky et al. 1998.

49. See, for example, Ardila et al. 2000a.

50. Petersson, Reis, and Ingvar 2001.

51. See, for example, Comings et al. 1998, Gray 1953, Dexter et al. 1998.

52. Garlick 2003.

53. For example, the speed with which infants engage in visual processing is related to later intelligence scores (Bukatko and Daehler, p. 343).

54. Fluid intelligence is essentially neural plasticity (Garlick 2003).

55. Haier et al. 2004. This relation between gray-matter density and performance may represent a general principle of brain organization (Mechelli et al. 2004).

56. Multiple intelligences theory (Gardner 2004).

57. Garlick 2003.

58. Stanovich 1999 proposes a two-tier system of intelligence, consisting of unconscious, automatic components as well as controlled processes that strip the context from a situation and judge whether an argument is valid. These skills can be learned.

59. Diamond 1988. Neuronal plasticity can be brought about through long-term potentiation. This means that if two neurons in the hippocampus are active at the same time, the connection between them can be strengthened. This change can last for hours to days and may lay a foundation for more permanent changes, such as the construction of new connections, or synapses, between the neurons (Rabenstein et al. 2005).

60. Neisser 1998. Intelligence tests were developed in the 1930s to have a mean of 100 and are expressed relative to a child's age. Although information-based performance improves throughout life, performance that requires reasoning stops developing after the brain stops growing (Garlick 2003).

61. Turkheimer, Haley, Waldron, D'Onofrio, and Gottesman 2003.

62. Duncan et al. 1994, Bolger et a. 1995.

63. Hoff and Pandey 2004.

64. This is called the Pygmalion effect (Rosenthal and Jacobson 1968).

65. Cited in OECD 2002, p. 74.

66. Callaghan et al. 2005.

67. Early hints involved research in Africa and the South Pacific (Gay and Cole 1967, Gladwin 1970).

68. Rogoff 2003.

69. Hudson 1960, 1962, cited in Rosselli and Ardila 2003.

70. Rosselli and Ardila 2003.

71. Ardila et al. 1989.

72. Mulenga, Ahonen and Aro 2001. Differences were within one standard deviation of U.S. norms.

73. Boivin et al. 1995. Zairian children needed about double the time of Canadian children and were about 25 percent less accurate.

74. León-Carrión, 1989. Differences were above one standard deviation of the Spanish sample.

75. Levine and Norenzayan 1999.

76. Global Monitoring Report 2005.

77. Seymour et al. 2003.

78. Camarata and Woodcock 2006.

79. Reported in Mustafa, van Dyk and Plon, pp. 52–56. The TIMSS 2003 survey found that grade 8 girls outperformed boys in algebra in 22 countries, while boys outscored girls only in 3.

80. According to a magazine article (Newsweek, September 19, 2005, p. 59), in primary-level gender-based curricula boys are allowed to do calisthenics in class to blow off energy, while girls get fluffy carpets on which to talk about their feelings as well as more time to complete tests.

81. Michaelowa 2001.

82. Marshall 2003.

83. Steinmetz et al. 2000. Neurons activated in response to a stimulus synchronize their activity in the 40–90 hertz range, which roughly corresponds to the hum of an electrical power outlet or fluorescent light. Synchronized firing of neurons may be a fundamental mechanism for boosting the volume of brain signals representing stimuli relevant to a behavior (Fries et al 2001).

84. The cognitive "budget" or attentional resources in effect refers to working memory (short-term memory) and the extent to which it holds the items that are attended. Working memory also declines with age (Figure 4.3).

85. Baddeley 1991. The novelty detector neurons quickly stop firing if a sound or sound pattern is repeated and briefly resume firing if some aspect of the sound changes. The neurons can detect changes in pitch, loudness, or duration of a single sound and can also note shifts in the pattern of a complex series of sounds and seem to act as gatekeepers, preventing information about unimportant sounds from reaching the brain's cortex, where higher processing occurs. This allows people to ignore sounds that don't require attention (Perez-Gonzalez et al. 2004).

86. If students sitting in the front of the class pay more attention, this may be due to the ability of the human voice to attract attention, the ability to see the blackboard clearly, and the likelihood that a teacher will ask a question to a child sitting nearby. In some countries, parents pay teachers to seat their children in the front of crowded classes (survey cited in Birdsall et al. 2004).

87. Berlyne 1965 (cited in Simon, 1986, p. 113).

88. Neural networks are software (or hardware) simulations of a biological brain, and their purpose is to learn to recognize patterns in data. Some types include Case Based Reasoning, Expert Systems, and Genetic Algorithms. Related fields include Classical Statistics, Fuzzy Logic, and Chaos Theory.

89. Polyn et al. 2005.

90. Hoffman and McNaughton 2002.

91. Illusions of competence (Bjork 1994, 1999).

92. Babies as young as five months old make distinctions about categories of events that their parents do not (Hespos and Spelke 2004).

93. Reisberg 2001, p. 298. Collins and Quillian (1969) proposed a hierarchical structure, which according to subsequent research is quite complex and not very neat. Searching the cognitive networks takes time, and concepts closer to the category prototype are retrieved faster (for example, a robin is a bird, versus a robin is an animal, versus a whale is a

mammal). Rosch 1978 proposed the prototype concept to deal with the intuitive understanding people develop about categories and their variations.

94. Dewhurst and Robinson 2004.

95. Rosch 1978; Reisberg 2001, p. 279.

96. Reisberg 2001, p. 244. Events that are witnessed frequently (such as what is done in a restaurant or a school) are encapsulated as *schemata*. People tend to reconstruct events in these much-used schemata rather than remember exactly what happened on the way to work 3 months earlier.

97. A video study of eight grade classes in countries with high and low scores in TIMSS showed significant differences in information processing. In the United States, which scored low, students were more often taught definitions and practiced routine procedures; they learned specific rules rather than the underlying rationale. Japanese students scored much higher. Teachers taught the principles that would enable students to solve complex problems, and they often connected abstract math topics to historical discoveries and real-world use. Problems solved in class were linked, creating a coherent knowledge structure. Students were asked to make mistakes and learn from them, a process reminiscent of generative learning (Annex II-B). Teachers also took advantage of students' ability to memorize, asking them to repeat rules that they immediately put into practice (Stigler and Hiebert 1999, p. 49). Deductive reasoning (math proofs) were used in 53 percent of Japanese classes and not at all in the U.S. classes. The study may also demonstrate the effect of distractions on consolidation; Japanese classes were never interrupted, while 31 percent of U.S. classes were interrupted for extraneous reasons.

98. Reisberg 2001, pp. 184, 186.

99. Gottfried et al. 2004.

100. Reisberg 2001, p. 168, citing Grant et al. 1998; Godden and Baddeley 1975.

101. Reisberg 2001, p. 168, citing Grant et al. 1998.

102. Carraher et al. 1985. Similar results have been obtained with odors (Reisberg 2001, p. 167, citing Schab 1990).

103. Reisberg 2001, p. 363.

104. Peretz et al. 2004. Melodies that are good cues are either well-learned, or easily learned.

105. This is because the brain circuits involved in visualizing or hearing with the mind's ear are the same as those involved in visual and auditory perception (Reisberg 2001, p. 346). Auditory imagery is surprisingly accurate and resistant to reinterpretation (somewhat like visual imagery). The mental playback of songs, for example, usually is in the same tempo and key as the original songs (Reisberg 2001, p. 369). Auditory imagery is useful for instruction, including foreign languages. If material presented in a foreign language is not deciphered fast enough to process the message within the duration of the working memory, auditory imaging may make the message available for longer-term processing. Songs preserve multiple auditory cues, so it might be possible to teach complex instructions to rural health workers (for example, midwives) by embedding them in songs.

106. Reisberg 2001, p. 362, Paivio 1969, 1971.

107. Paivio 1969, 1971.

108. Malone 1980, Baltra 1990, Lepper and Malone 1987, Kafai 1997, cited in OECD-OECD-CERI 2003a. Surprise creates positive feelings when the circumstances are benign, but it is stressful when the circumstances are harmful. The neurotransmitter dopamine gets secreted under positive circumstances, often in anticipation of a pleasurable event.

109. Children seem more capable of classifying items on the basis of similarity rather than through inductive reasoning, in which a person uses particular facts to reach general principles. Five-year-old children who classified items (for example, whether an animal was a cat) on the basis of similarity were found to be more accurate than adults in recognizing them later. When told to classify on the basis of category they became less accurate, possibly because they focused on the less salient aspects of concepts (Sloutsky and Fisher 2004). Dewhurst and Robinson 2004 researched the tendency to recall falsely words that are semantically related to a list of words. Eleven-year-olds performed in the same way as adults and falsely recalled words that were semantically related to the lists; 8-year-olds were equally likely to falsely recall rhymes and semantic associates; and 5-year-olds falsely recalled words that rhymed with those presented in the lists. Young children's tendency to remember items on the basis of sound rather than meaning points to potentially different strategies for the early grades.

110. In Reisberg 2001, p. 174 (citing Barz 1976, Glenberg and Adams 1978, Glenberg, Smith, and Green 1977, Woodward, Bjork, and Jongeward 1973).

111. Reisberg 2001, p. 169, citing Fisher and Craig 1977.

112. The levels of processing have analogies to the cognitive domain of Bloom's taxonomy of instructional objectives known to educators: information, comprehension, application, analysis, synthesis, evaluation (Bloom et al. 1971). Cognitive psychologists have debated whether memory is a continuum represented by levels of processing (Craik and Lockhart's single memory system) or whether there are different memory stores, as shown in the structure of memory section (Atkinson and Shiffrin multistore model). Neuroscience has shown that memories are stored in multiple areas of the brain, but the integration details are still unclear. For instructional purposes both models are useful.

113. First-letter mnemonics are apparently the method used to construct the Phoenician ideograms that ultimately led to the Latin alphabet through Greek. A, B, C, D, and so forth originally were designs alluding to the first sound of a word they represented (alef, beit, gimel, dalet, and so forth) which turned into Hebrew, Arabic, and Greek letters. These languages actually maintain the original names of many letters, though their real meaning is lost to many people.

114. Reisberg 2001, p. 165.

115. Noice and Noice 2002.

116. Soraci et al. 2003. People are more likely to remember accurately words that involved some generation of missing characters when the cue was negative (for example, "not part of something") and also to remember correctly a word under such a condition rather than make mistakes.

117. Tested just two days after learning, students who had only studied a test had forgotten much of what they had learned and scored lower than students who had been subjected to repeated testing. Tested one week later, the study-test-test-test group scored dramatically

better, remembering 61 percent of the passage as compared with only 40 percent by the study-only group. The study-only group had read the passage about 14 times, but still recalled less than the repeated testing group, which had read the passage only 3.4 times in its one-and-only study session (Roediger and Karpicke 2006).

118. See, for example, Archer and Cottingham 1996.

119. Berns et al. 2001.

120. Reisberg 2001, p. 242.

121. If the relationship among pieces of information is not clarified, the information cannot be put to use. For example, students were asked to remember or recall three sentences: "the short man picked up the broom," "the short man picked up the broom to operate the light switch," and "the short man picked up the broom to sweep the floor." The students were more likely to remember the last sentence that explained why a broom was needed (Stein et al. 1984).

122. Reisberg 2001, p. 154.

123. Cole and Cole 2001.

124. Cermak and Wong, 2000. Consolidation may require several days, and the categories needed to store information may not get consolidated in sufficient time. The effect may also due to the information restructuring that takes place during sleep (Fenn et al. 2003).

125. See, for example, Glewwe et al. 2003. See more in Solso 1988 and Reisberg 2001.

126. Smith and Rothkopf 1984, Baddeley and Longman 1978.

127. Bahrick and Hall 2005.

128. Glewwe et al. 2003.

129. This is called the Zeigarnik effect (Zeigarnik 1969) and has been repeatedly confirmed (Savitsky, Medvec, and Gilovich 1997, Greenberg and Malcolm, 2002, Rotello 1999). The phenomenon may be explained by the tendency of the prefrontal cortex to maintain memories ready to use and lists of things to do. Fuji and Graybiel (2003) found that monkey neurons whose activity they recorded had an "extra" response when the monkeys finished the entire sequence of movements.

130. Several children in Yemen reported on an IEG mission in 2004 that they liked Koranic recitation. In "traditional" teaching situations where written materials are few, children indeed need to sit and listen quietly.

131. Sternberg and Ben-Zeev, p. 292.

132. An example is given by Gay and Cole 1967. They asked a Liberian student questions about arithmetic, and he launched into a singsong patter ("La lala lala, la lala lala, la lala lala"). Asked what he was doing, he answered that he was adding numbers, but that so far he had only learned the tune and not yet the words.

133. OED 2005.

134. Dewhurst and Robinson 2004.

135. The limited emphasis on memorizing math functions has been criticized severely as being responsible for lowering U.S. test scores in math (Pinker pp. 341–343).

136. Barrier et al. 1998.

137. Peper and Mayer 1978.

138. Howe 1970.

139. Schoups, Vogels, and Orhan 1995, cited in Sekuler and Blake 2001, p. 231; also Neisser 1964.

140. Woolfolk, pp. 310–312.

141. Bjork and Richardson-Klavhen 1989.

142. Gick and Holyoak 1983.

143. There are two traditional theories of forgetting. One argues that the memory trace simply fades and the other that forgetting occurs because memory traces are disrupted or obscured by subsequent learning (proactive and retroactive inhibition). Interference is usually a more important factor in forgetting than a faded memory trace (Baddeley 1999). A more recent theory of disuse suggests that information does not decay, but may become inaccessible due to a lack of practice (Robert Bjork, 2002, personal communication). Neuroscience suggests that incomplete consolidation may be responsible for some of the forgetting.

144. See, for example, Loftus 1997.

145. Baddeley 1999.

146. Schachter p. 9.

147. Reisberg 2001, p. 225.

148. Bahrick 1979.

149. McKenna and Glendon 1985.

150. Wisher 1992.

151. Bjork and Bjork 1992.

152. Divergent thinking involves preparation, incubation (when the person is not consciously thinking about a problem), a moment of illumination, and verification. There may be a back and forth process. (Sternberg and Ben-Zeev 2001).

153. Rotter 1966. Lower-income students more often have an "external locus of control" (Miller et al. 2003).

154. OECD-CERI 2002. Other learning style configurations include preferences for (a) visual—using pictures, images, and spatial understanding; (b) aural—using sound and music; (c) verbal—using words, both in speech and writing; (d) physical—using your body, hands, and sense of touch; (e) logical—using logic, reasoning, and systems; (f) social—learning in groups or with other people; (g) solitary—working alone and using self-study (www.accelerated-learning-online.com/styles/default.asp).

155. Gardner 2004.

156. Sternberg and Ben-Zeev, pp. 296–297.

157. Pioneering work was done by Amos Tversky and Daniel Kahneman. Kahneman won the 2002 economics Nobel Prize for the behavioral economics concepts based on memory issues.

158. Reisberg, pp. 432–433.

159. These include covariation illusions and theory-based judgments (Reisberg p. 388, citing Chapman and Chapman 1971).

160. Pritchett 2001 (cited in Dugger 2004).

161. Diffusion of responsibility (Latané et al. 1979).

162. Schachter 2001, pp. 51–60. This activity relies on planning and scheduling abilities and executive functioning that is typically located in the frontal lobes. One must encode an intention, retain the information, execute the intention when the time or circumstances come, and then evaluate the outcome.

163. OECD-CERI 2002.

164. Lu et al. 2004.

165. Myelin is a sheet of fat, with very high cholesterol content that can wrap tightly around axons, and speeds messages through the brain by insulating these neural "wire" connections. As the brain continues to develop in adulthood and as myelin is produced in greater and greater quantities, cholesterol levels in the brain rise and eventually promote the production of a toxic protein. The protein attacks myelin, disrupts message transfer through the axons and may eventually lead to the destructive plaques and tangles visible years later in the cortex of Alzheimer's patients. Complex connections that take the longest to develop and allow humans to think at their highest level are among the first to deteriorate as the brain's myelin breaks down. The challenge for researchers is to figure out how to extend the brain's peak performance so that the minds function as long as the bodies (Bartzokis 2004).

166. In general, the parts of the brain that handle learning and memory tasks are replete with receptors for testosterone (Nagourney 2002). Older men with higher levels of bioavailable testosterone that can reach the brain may do significantly better on these cognitive tests than men with lower levels (Yaffe et al. 2002).

167. Estrogen improves oral reading and verbal memory performance in younger postmenopausal women (Shaywitz et al. 2003).

168. Madden et al. 2003.

169. For example, when elderly and young people were asked to determine the accuracy of a math calculation ((10 x 9) + 8 = 98), their performance was equivalent. But when seniors were presented with a word in addition to the math problem, and were asked to remember it, their performance dropped dramatically. This suggests that the active memory span becomes less efficient with age (Reuter-Lorenz 2001).

170. Graf and Masson 1993, Newcombe et al. 2000.

171. In studies of more than 350 men and women between the ages of 20 and 90, processing power loss was found to start as soon as our 20s. Younger adults in their 20s and 30s notice no losses at all, even though they are declining at the same rate as people in their 60s and 70s, because they have more capital than they need (Park 2001).

172. For example, Milham et al. 2002 on attention control.

173. Schachter 2001, p. 20.

174. OECD-CERI 2002, Logan et al. 2002 showed that the aged did not recruit the left frontal cortical regions as much as young people. But the elderly could improve focus and retention of a word list if they made a decision about the category a word fell in, (for example, whether it pertained to something abstract or something concrete).

175. OECD CERI 2002, p. 67.

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Index

Large-scale efforts have been made since the 1990s to ensure that all children of the world go to school. But mere enrollment is not sufficient; students must become fluent in reading and calculation by the end of grade 2. Fluency is needed to process large amounts of text quickly and use the information for decisions that may ultimately reduce poverty. State-of-the-art brain imaging and cognitive psychology research can help formulate effective policies for improving the basic skills of low-income students.

This book integrates research into applications that extend from preschool brain development to the memory of adult educators. In layman's terms, it provides explanations and answers to questions such as:

- Why do children have to read fast before they can understand what they read?
- How do health, nutrition, and stimulation influence brain development?
- Why should students learn basic skills in their maternal language?
- Is there such a thing as an untrained teacher?
- What signs in a classroom show whether students are getting a quality education?
- How must information be presented in class so that students can retain it and use it?
- What training techniques are most likely to help staff put their learning into use?

This book would be useful to policy makers, donor agency staff, teacher trainers, supervisors, and inspectors, as well as university professors and students.

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