EARLY CHILDHOOD DEVELOPMENT AND LEARNING

NEW KNOWLEDGE FOR POLICY

Division of Behavioral and Social Sciences and Education
National Research Council
National Academies

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Overview

The National Research Council of the National Academies has been charged by Congress with ensuring that the best scientific understanding illuminates key challenges facing the nation and informs policy choices. Few challenges are more crucial than fostering the healthy development of America's children and their capacity to learn and achieve success in school. Child development, learning, and education have been high priorities of the National Academies in the past two decades. An explosion— and *convergence*—of knowledge from the cognitive, behavioral, social, and neurosciences has brought into much sharper focus the picture of how human development unfolds and the factors that determine whether children are equipped to learn and to flourish. With the nation's attention focused on the need to improve children's educational achievement, science has much to offer in making gains toward that end.

Compelling new scientific evidence reveals that a child's earliest experiences have a major role in shaping the likelihood of getting off to a good start in life and school, for these are the years when the essential structures for growth and learning are put in place. These findings have important implications for the content of child care and early education programs and highlight the public interest in assuring the quality of those programs.

Similarly, decades of research on the science of learning has shown that deep understanding requires *both* a rich foundation of factual knowledge and command of the subject's conceptual frameworks—whether it be chess, mathematics, or jet engine mechanics. This research has impor

tant implications for educational practice—what and how teachers teach— and for policy, for example, state education standards.

This booklet includes executive summaries of five reports that, taken together, provide policy makers, educators, and parents with important tools for progress. It is intended for federal administrators, members of Congress, leaders of nongovernmental organizations, and others who want to use the best available science to develop policies to promote child development and education. Conducted under the auspices of the Division of Behavioral and Social Sciences and Education of the National Research Council—the Academies' operating arm —and the Institute of Medicine, these studies exemplify the contributions of science in charting new directions for policies and programs.

From Neurons to Neighborhoods: The Science of Early Childhood Development integrates the latest scientific evidence about children's extraordinary capacities for physical, emotional, and social growth and learning in the earliest years of their lives. Well before they walk through a classroom door, these early experiences matter because they can provide opportunities or obstacles that affect early learning and subsequent academic success. Yet far too little attention is given to these crucial years.

Today as never before, the nation needs to apply advancing knowledge to help children and families negotiate the changing demands and opportunities as we enter the 21st century. Dramatic transformations have occurred in the social and economic circumstances of families with young children. The number of working parents has increased significantly, leading to a pressing demand for quality child care and greater difficulty in balancing work and family responsibilities for families at all income levels. Despite these and other changes, our nation's responses to the needs of young children and their families were largely formulated decades ago with only incremental revisions since then.

From Neurons to Neighborhoods presents conclusions and recommendations drawn from a rich and extensive knowledge base and grounded in four core themes:

- All children are born wired for feelings and ready to learn.
- Early environments matter and nurturing relationships are essential.
- Society is changing and the needs of young children are not being addressed.
- Interactions among early childhood science, policy, and practice demand dramatic rethinking.

From Neurons to Neighborhoods, which has received considerable attention in the media, offers an authoritative guide to what science-based

policies would mean for our society's youngest members. For example, research highlights the need for early childhood programs that balance their focus on literacy and numeracy skills with comparable attention to the emotional, regulatory, and social development of all children, including those with special needs. Investments in child care should ensure that all early care and education settings are safe, stimulating, and compatible with the values and priorities of their families. Nurturing and sustained relationships between preschoolers and qualified caregivers are essential, and the time for greater skills, compensation, and benefits for child care professionals is long overdue. This comprehensive study calls for a federal-state-local task force to review public investments in child care and early education and develop a blueprint for a high quality, locally responsive system for the new decade.

Eager to Learn: Educating Our Preschoolers explores what it will take to provide early education and care for children that would develop their impressive learning potential. The report integrates recent research findings on how young children learn and the impact of early learning on later development and school achievement. Reinforcing many of the findings in *From Neurons to Neighborhoods,* it highlights the importance of warm emotional relationships with adults in fostering a child's cognitive as well as social development. It includes findings about the interplay of biology and environment, and variations in learning preparedness among children from different social and economic groups. The report probes a number of key issues:

- The importance of a responsive teacher-child relationship in a child's cognitive, social, and emotional development.
- The substantial variation among children in developmental pathways, temperament, and environmental and cultural influences.
- The learning needs of disadvantaged children and children with disabilities.
- Evidence regarding the features of preschool programs, curricula, and teaching style that produce positive outcomes for children.
- Preparation and continuing development of teachers.

Eager to Learn issues a range of recommendations to parents, educators, and policy makers. It calls for a substantial investment in a high-quality system of child care and preschool on the basis of the convergence of scientific and practical considerations. And it calls for systematic and widespread public education to increase public understanding of the importance of stimulating early learning experiences in the lives of young children.

Preventing Reading Difficulties in Young Children is a ground-breaking study of the process of learning to read, factors that predict success and failure in reading, and instructional strategies for overcoming potential stumbling blocks on the path to literacy. A companion book, ***Starting Out Right—A Guide to Promoting Children's Reading Success,*** describes the skills that young children (from birth to age 8) need to accumulate and provides illustrative examples of activities that will help them develop those skills. This popular and invaluable resource for parents, caregivers, and teachers includes practical guidelines, advice on resources, program descriptions, and strategies for everyday life—all based on the underlying concepts presented in *Preventing Reading Difficulties in Young Children* and supported by scientific research.

With literacy problems plaguing as many as four in ten children in America, the teaching of reading has for decades evoked heated debate and fierce battles over curricula, frustrating parents, educators, and policy makers alike. In contrast to the narrow solutions that defined the old battle lines, these reports show skilled reading to be a complex and multifaceted process. Good readers master three main accomplishments:

- They understand the system of sound/spelling connections used in English to identify printed words.
- They are able to use previous knowledge, vocabulary, and comprehension strategies to obtain meaning from print.
- They read fluently enough to understand what they read and to enjoy reading.

Good instruction focuses on all three kinds of accomplishment in an integrated way that enables young readers to develop increasing proficiency in all of them.

Research consistently demonstrates that the more children know about language before they arrive at school, the better equipped they are to succeed in reading. The foundation for skilled reading is provided by responsive parents and caregivers who read to infants and toddlers, talk and listen to them, help them understand stories and how things work, and develop their awareness of how words sound and how they look on a page and their motivation to read. Equally important is high quality reading instruction in the first years of schooling. Preventing reading difficulties or addressing them early has a far higher likelihood of success than trying to reverse deeply entrenched reading problems.

While there is still a good deal to be learned about the specifics of effective reading instruction in the primary grades, *Preventing Reading Difficulties in Young Children* provides the core principles on which suc

cessful programs need to build, and *Starting Out Right* provides practical examples of the types of activities that will bring those principles to life.

How People Learn: Brain, Mind, Experience and School (Expanded Edition) integrates research from the variety of fields that contributes to our understanding of human learning and relates it to educational practice in schools. From research on cognition, brain development, learning, and teaching, the report knits together a rich knowledge base that significantly advances understanding of what it means to know—from the neural processes that occur during learning to the influence of culture on what individuals see and absorb. It suggests principles of learning with clear implications for what we teach, how we teach, and how we assess student learning. The findings in the report call into question concepts and practices commonly used in our schools, and illustrate how approaches based on what is now known can result in in-depth learning.

Topics include:

- the amazing learning potential of infants;
- how learning actually changes the physical structure of the brain;
- how existing knowledge affects what people notice and how they learn; and
- what the thought processes of experts tell us about how to teach.

The expanded edition looks further at the agenda the nation must tackle to employ the best research in classroom practice. Incorporating learning principles into teaching materials, teacher education, education policy (such as standards for content and accountability), and public understanding—all are keys to success. *How People Learn o*ffers recommendations for a sustained effort to consolidate knowledge on teaching and learning, and aligning the efforts of teachers, educators, parents, and policy makers.

Improving Student Learning: A Strategic Plan for Education Research and Its Utilization speaks to the urgent need to strengthen public education and, in particular, to improve the educational achievement of youngsters growing up in conditions of social and economic disadvantage. The nation's continued vitality as a democracy and productivity in the global economy hinge on the knowledge and skills of the majority of its people. While many students perform at high levels, there are millions who will be ill-equipped to meet the intellectual demands of modern life and work. The pronounced failure of many big-city schools that serve poor children is of particular concern.

Education in the United States consumes more than 7 percent of GDP. *Improving Student Learning: A Strategic Plan for Education Research and its Utilization* calls for an ambitious and intensive 15-year program of research and implementation that has the potential to leverage substantial improvements in student performance. The goal of the Strategic Education Research Program (SERP) is to change the landscape fundamentally, to achieve permanent improvements in education by institutionalizing strategies, incentives, and enduring relationships between educators and the research community so that the use of salient research in educational settings becomes smooth, practiced, and effective.

The plan addresses four key questions:

- How can advances in research on human cognition, development, and learning be incorporated into educational practice?
- How can student engagement in the learning process and motivation to achieve in school be increased?
- How can schools and school districts be transformed into organizations that have the capacity to continuously improve their practices?
- How can the use of research knowledge be increased in schools and school districts?

Each of these four questions would provide the basis for a network of expert and committed researchers, state and local practitioners, and policy makers. The networks would be devoted to synthesizing what we know in each of the four areas, extending our understanding through the conduct of new research, and developing the mechanisms for effective use of research knowledge in the classroom. This proposal for a bold initiative to harness the power of science to public drive for school reform will be the focus of a planning and coalition-building campaign for the year 2001 by the National Research Council, with support from the Department of Education, the MacArthur Foundation, and the Carnegie Corporation.

AVAILABILITY INFORMATION

The reports highlighted here are a sampling of the kinds of information available from the National Academies. A list of recent related publications appears at the end of this booklet. The Division of Social and Behavioral Sciences and Education can provide copies of the full volumes summarized here as well as discuss any of the findings or recommendations they present.

To request additional information, please contact Paula Melville, Administrative Associate, at 202-334-2300. For a list of the Division's key

staff, please see page 103. Information on other reports and current and planned projects of the Division of Social and Behavioral Sciences and Education is available at www.nationalacademies.org/dbasse . Reports of the National Academies are available at www.nap.edu .

From Neurons to Neighborhoods

The Science of Early Childhood Development

Committee on Integrating the Science of Early Childhood Development

Jack P. Shonkoff and Deborah A. Phillips, *Editors*

Board on Children, Youth, and Families

National Research Council and Institute of Medicine

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Executive Summary

Scientists have had a long-standing fascination with the complexities of the process of human development. Parents have always been captivated by the rapid growth and development that characterize the earliest years of their children's lives. Professional service providers continue to search for new knowledge to inform their work. Consequently, one of the distinctive features of the science of early childhood development is the extent to which it evolves under the anxious and eager eyes of millions of families, policy makers, and service providers who seek authoritative guidance as they address the challenges of promoting the health and well-being of young children.

PUTTING THE STUDY IN CONTEXT

Two profound changes over the past several decades have coincided to produce a dramatically altered landscape for early childhood policy, service delivery, and childrearing in the United States. First, an explosion of research in the neurobiological, behavioral, and social sciences has led to major advances in understanding the conditions that influence whether children get off to a promising or a worrisome start in life. These scientific gains have generated a much deeper appreciation of: (1) the importance of early life experiences, as well as the inseparable and highly interactive influences of genetics and environment, on the development of the brain and the unfolding of human behavior; (2) the central role of early relationships as a source of either support and adaptation or risk and dysfunc

tion; (3) the powerful capabilities, complex emotions, and essential social skills that develop during the earliest years of life, and (4) the capacity to increase the odds of favorable developmental outcomes through planned interventions.

Second, the capacity to use this knowledge constructively has been constrained by a number of dramatic transformations in the social and economic circumstances under which families with young children are living in the United States: (1) marked changes in the nature, schedule, and amount of work engaged in by parents of young children and greater difficulty balancing workplace and family responsibilities for parents at all income levels; (2) continuing high levels of economic hardship among families, despite overall increases in maternal education, increased rates of parent employment, and a strong economy; (3) increasing cultural diversity and the persistence of significant racial and ethnic disparities in health and developmental outcomes; 4) growing numbers of young children spending considerable time in child care settings of highly variable quality, starting in infancy; and (5) greater awareness of the negative effects of stress on young children, particularly as a result of serious family problems and adverse community conditions that are detrimental to child well-being. While any given child may be affected by only one or two of these changes, their cumulative effects on the 24 million infants, toddlers, and preschoolers who are now growing up in the United States warrant dedicated attention and thoughtful response.

This convergence of advancing knowledge and changing circumstances calls for a fundamental reexamination of the nation's responses to the needs of young children and their families, many of which were formulated several decades ago and revised only incrementally since then. It demands that scientists, policy makers, business and community leaders, practitioners, and parents work together to identify and sustain policies and practices that are effective, generate new strategies to replace those that are not achieving their objectives, and consider new approaches to address new goals as needed. It is the strong conviction of this committee that the nation has not capitalized sufficiently on the knowledge that has been gained from nearly half a century of considerable public investment in research on children from birth to age 5. In many respects, we have barely begun to use our growing research capabilities to help children and families negotiate the changing demands and possibilities of life in the 21st century.

THE COMMITTEE'S CHARGE

The Committee on Integrating the Science of Early Childhood Development was established by the Board on Children, Youth, and Families of

the National Research Council and the Institute of Medicine to update scientific knowledge about the nature of early development and the role of early experiences, to disentangle such knowledge from erroneous popular beliefs or misunderstandings, and to discuss the implications of this knowledge base for early childhood policy, practice, professional development, and research.

The body of research that the committee reviewed is extensive, multidisciplinary, and more complex than current discourse would lead one to believe. It covers the period from before birth until the first day of kindergarten. It includes efforts to understand how early experience affects all aspects of development—from the neural circuitry of the maturing brain, to the expanding network of a child's social relationships, to both the enduring and the changing cultural values of the society in which parents raise children. It includes efforts to understand the typical trajectories of early childhood, as well as the atypical developmental pathways that characterize the adaptations of children with disabilities.

The committee's review of this evidence addresses two complementary agendas. The first is focused on the future and asks: How can society use knowledge about early childhood development to maximize the nation's human capital and ensure the ongoing vitality of its democratic institutions? The second is focused on the present and asks: How can the nation use knowledge to nurture, protect, and ensure the health and well-being of all young children as an important objective in its own right, regardless of whether measurable returns can be documented in the future? The first agenda speaks to society's economic, political, and social interests. The second speaks to its ethical and moral values. The committee is clear in our responsibility to speak to both.

CORE CONCEPTS OF DEVELOPMENT

As the knowledge generated by interdisciplinary developmental science has evolved and been integrated with lessons from program evaluation and professional experience, a number of core concepts, which are elaborated in the report, have come to frame understanding of the nature of early human development.

1. Human development is shaped by a dynamic and continuous interaction between biology and experience.
2. Culture influences every aspect of human development and is reflected in childrearing beliefs and practices designed to promote healthy adaptation.
3. The growth of self-regulation is a cornerstone of early childhood development that cuts across all domains of behavior.

4. Children are active participants in their own development, reflecting the intrinsic human drive to explore and master one's environment.
5. Human relationships, and the effects of relationships on relationships, are the building blocks of healthy development.
6. The broad range of individual differences among young children often makes it difficult to distinguish normal variations and maturational delays from transient disorders and persistent impairments.
7. The development of children unfolds along individual pathways whose trajectories are characterized by continuities and discontinuities, as well as by a series of significant transitions.
8. Human development is shaped by the ongoing interplay among sources of vulnerability and sources of resilience.
9. The timing of early experiences can matter, but, more often than not, the developing child remains vulnerable to risks and open to protective influences throughout the early years of life and into adulthood.
10. The course of development can be altered in early childhood by effective interventions that change the balance between risk and protection, thereby shifting the odds in favor of more adaptive outcomes.

POLICY AND PRACTICE

The committee's conclusions and recommendations are derived from a rich and extensive knowledge base and are firmly grounded in the following four overarching themes:

- All children are born wired for feelings and ready to learn.
- Early environments matter and nurturing relationships are essential.
- Society is changing and the needs of young children are not being addressed.
- Interactions among early childhood science, policy, and practice are problematic and demand dramatic rethinking.

All Children Are Born Wired for Feelings and Ready to Learn

From the time of conception to the first day of kindergarten, development proceeds at a pace exceeding that of any subsequent stage of life. Efforts to understand this process have revealed the myriad and remarkable accomplishments of the early childhood period, as well as the serious problems that confront some young children and their families long before school entry. A fundamental paradox exists and is unavoidable: development in the early years is both highly robust and highly vulnerable. Although there have been long-standing debates about how much the

early years really matter in the larger scheme of lifelong development, our conclusion is unequivocal: What happens during the first months and years of life matters a lot, not because this period of development provides an indelible blueprint for adult well-being, but because it sets either a sturdy or fragile stage for what follows.

Conclusions

- From birth to age 5, children rapidly develop foundational capabilities on which subsequent development builds. In addition to their remarkable linguistic and cognitive gains, they exhibit dramatic progress in their emotional, social, regulatory, and moral capacities. All of these critical dimensions of early development are intertwined, and each requires focused attention.
- Striking disparities in what children know and can do are evident well before they enter kindergarten. These differences are strongly associated with social and economic circumstances, and they are predictive of subsequent academic performance. Redressing these disparities is critical, both for the children whose life opportunities are at stake and for a society whose goals demand that children be prepared to begin school, achieve academic success, and ultimately sustain economic independence and engage constructively with others as adult citizens.
- Early child development can be seriously compromised by social, regulatory, and emotional impairments. Indeed, young children are capable of deep and lasting sadness, grief, and disorganization in response to trauma, loss, and early personal rejection. Given the substantial short-and long-term risks that accompany early mental health impairments, the incapacity of many early childhood programs to address these concerns and the severe shortage of early childhood professionals with mental health expertise are urgent problems.

Recommendations

- **Recommendation 1** — Resources on a par with those focused on literacy and numerical skills should be devoted to translating the knowledge base on young children's emotional, regulatory, and social development into effective strategies for fostering: (1) the development of curiosity, self-direction, and persistence in learning situations; (2) the ability to cooperate, demonstrate caring, and resolve conflict with peers; and (3) the capacity to experience the enhanced motivation associated with feeling competent and loved. Such strategies and their widespread diffusion into

the early childhood field must encompass young children both with and without special needs. Successful action on this recommendation will require the long-term, collaborative investment of government, professional organizations, private philanthropy, and voluntary associations.

- **Recommendation 2** — School readiness initiatives should be judged not only on the basis of their effectiveness in improving the performance of the children they reach, but also on the extent to which they make progress in reducing the significant disparities that are observed at school entry in the skills of young children with differing backgrounds.
- **Recommendation 3** — Substantial new investments should be made to address the nation's seriously inadequate capacity for addressing young children's mental health needs. Expanded opportunities for professional training, as recently called for by the Surgeon General, and incentives for individuals with pertinent expertise to work in settings with young children are essential first steps toward more effective screening, early detection, treatment, and ultimate prevention of serious childhood mental health problems.

Early Environments Matter and Nurturing Relationships Are Essential

The scientific evidence on the significant developmental impacts of early experiences, caregiving relationships, and environmental threats is incontrovertible. Virtually every aspect of early human development, from the brain's evolving circuitry to the child's capacity for empathy, is affected by the environments and experiences that are encountered in a cumulative fashion, beginning early in the prenatal period and extending throughout the early childhood years. The science of early development is also clear about the specific importance of parenting and of regular caregiving relationships more generally. The question today is not whether early experience matters, but rather how early experiences shape individual development and contribute to children's continued movement along positive pathways.

Conclusions

- The long-standing debate about the importance of nature *versus* nurture, considered as independent influences, is overly simplistic and scientifically obsolete. Scientists have shifted their focus to take account of the fact that genetic and environmental influences work together in dynamic ways over the course of development. At any time, both are sources of human potential and growth as well as risk and dysfunction. Both genetically determined characteristics and those that are highly affected by experience are open to intervention. The most important questions now

concern how environments influence the expression of genes and how genetic makeup, combined with children's previous experiences, affects their on-going interactions with their environments during the early years and beyond.

- Parents and other regular caregivers in children's lives are "active ingredients" of environmental influence during the early childhood period. Children grow and thrive in the context of close and dependable relationships that provide love and nurturance, security, responsive interaction, and encouragement for exploration. Without at least one such relationship, development is disrupted and the consequences can be severe and long-lasting. If provided or restored, however, a sensitive caregiving relationship can foster remarkable recovery.
- Children's early development depends on the health and well-being of their parents. Yet the daily experiences of a significant number of young children are burdened by untreated mental health problems in their families, recurrent exposure to family violence, and the psychological fallout from living in a demoralized and violent neighborhood. Circumstances characterized by multiple, interrelated, and cumulative risk factors impose particularly heavy developmental burdens during early childhood and are the most likely to incur substantial costs to both the individual and society in the future.
- The time is long overdue for society to recognize the significance of out-of-home relationships for young children, to esteem those who care for them when their parents are not available, and to compensate them adequately as a means of supporting stability and quality in these relationships for all children, regardless of their family's income and irrespective of their developmental needs.
- Early experiences clearly affect the development of the brain. Yet the recent focus on "zero to three" as a critical or particularly sensitive period is highly problematic, not because this isn't an important period for the developing brain, but simply because the disproportionate attention to the period from birth to 3 years begins too late and ends too soon.
- Abundant evidence from the behavioral and the neurobiological sciences has documented a wide range of environmental threats to the developing central nervous system. These include poor nutrition, specific infections, environmental toxins, and drug exposures, beginning early in the prenatal period, as well as chronic stress stemming from abuse or neglect throughout the early childhood years and beyond.

Recommendations

- **Recommendation 4** — Decision makers at all levels of government, as well as leaders from the business community, should ensure that better public and private policies provide parents with viable choices about how to allocate responsibility for child care during the early years of their children's lives. During infancy, there is a pressing need to strike a better balance between options that support parents to care for their infants at home and those that provide affordable, quality child care that enables them to work or go to school. This calls for expanding coverage of the Family and Medical Leave Act to all working parents, pursuing the complex issue of income protection, lengthening the exemption period before states require parents of infants to work as part of welfare reform, and enhancing parents' opportunities to choose from among a range of child care settings that offer the stable, sensitive, and linguistically rich caregiving that fosters positive early childhood development.
- **Recommendation 5** — Environmental protection, reproductive health services, and early intervention efforts should be substantially expanded to reduce documented risks that arise from harmful prenatal and early postnatal neurotoxic exposures, as well as from seriously disrupted early relationships due to chronic mental health problems, substance abuse, and violence in families. The magnitude of these initiatives should be comparable to the attention and resources that have been dedicated to crime prevention, smoking cessation, and the reduction of teen pregnancy. They will require the participation of multiple societal sectors (e.g., private, public, and philanthropic) and the development of multiple strategies.
- **Recommendation 6** — The major funding sources for child care and early childhood education should set aside a dedicated portion of funds to support initiatives that jointly improve the qualifications and increase the compensation and benefits routinely provided to children's nonparental caregivers. These initiatives can be built on the successful experience of the U.S. Department of Defense.

Society Is Changing and the Needs of Young Children Are Not Being Addressed

Profound social and economic transformations are posing serious challenges to the efforts of parents and others to strike a healthy balance between spending time with their children, securing their economic needs, and protecting them from the many risks beyond the home that may have an adverse impact on their health and development.

Conclusions

- Changing parental work patterns are transforming family life. Growing numbers of young children are being raised by working parents whose earnings are inadequate to lift their families out of poverty, whose work entails long and nonstandard hours, and whose economic needs require an early return to work after the birth of a baby. The consequences of the changing context of parental employment for young children are likely to hinge on how it affects the parenting they receive and the quality of the caregiving they experience when they are not with their parents.
- The developmental effects of child care depend on its safety, the opportunities it provides for nurturing and stable relationships, and its provision of linguistically and cognitively rich environments. Yet the child care that is available in the United States today is highly fragmented and characterized by marked variation in quality, ranging from rich, growth-promoting experiences to unstimulating, highly unstable, and sometimes dangerous settings. The burden of poor quality and limited choice rests most heavily on low-income, working families whose financial resources are too high to qualify for subsidies yet too low to afford quality care.
- Young children are the poorest members of society and are more likely to be poor today than they were 25 years ago. Growing up in poverty greatly increases the probability that a child will be exposed to environments and experiences that impose significant burdens on his or her well-being, thereby shifting the odds toward more adverse developmental outcomes. Poverty during the early childhood period may be more damaging than poverty experienced at later ages, particularly with respect to eventual academic attainment. The dual risk of poverty experienced simultaneously in the family and in the surrounding neighborhood, which affects minority children to a much greater extent than other children, increases young children's vulnerability to adverse consequences.

Recommendations

The challenges that arise at the juxtaposition of work, income, and the care of children reflect some of the most complex problems of contemporary society. Rather than offer recommendations for specific actions, many of which have been made before and gone unheeded, the committee wishes to underscore the compelling need for a focused, integrative, and comprehensive reassessment of our nation's child care and income support policies.

- **Recommendation 7** — The President should establish a joint federal-state-local task force charged with reviewing the entire portfolio of public investments in child care and early education. Its goal should be to develop a blueprint for locally responsive systems of early care and education for the coming decade that will ensure the following priorities: (1) that young children's needs are met through sustained relationships with qualified caregivers, (2) that the special needs of children with developmental disabilities or chronic health conditions are addressed, and (3) that the settings in which children spend their time are safe, stimulating, and compatible with the values and priorities of their families.
- **Recommendation 8** — The President's Council of Economic Advisers and the Congress should assess the nation's tax, wage, and income support policies with regard to their adequacy in ensuring that no child who is supported by the equivalent of a full-time working adult lives in poverty and that no family suffers from deep and persistent poverty, regardless of employment status. The product of this effort should be a set of policy alternatives that would move the nation toward achieving these fundamental goals.

Interactions Among Early Childhood Science, Policy, and Practice Are Problematic and Demand Dramatic Rethinking

Policies and programs aimed at improving the life chances of young children come in many varieties. Some are home based and others are delivered in centers. Some focus on children alone or in groups, and others work primarily with parents. A variety of services have been designed to address the needs of young children whose future prospects are threatened by socioeconomic disadvantages, family disruptions, and diagnosed disabilities. They all share a belief that early childhood development is susceptible to environmental influences and that wise public investments in young children can increase the odds of favorable developmental outcomes. The scientific evidence resoundingly supports these premises.

Conclusions

- The overarching question of whether we can intervene successfully in young children's lives has been answered in the affirmative and should be put to rest. However, interventions that work are rarely simple, inexpensive, or easy to implement. The critical agenda for early childhood intervention is to advance understanding of what it takes to improve the odds of positive outcomes for the nation's most vulnerable young children and to determine the most cost-effective strategies for achieving well-defined goals.

- The scientific knowledge base guiding early childhood policies and programs is seriously constrained by the relatively limited availability of systematic and rigorous evaluations of program implementation; gaps in the documentation of causal relations between specific interventions and specific outcomes and of the underlying mechanisms of change; and infrequent assessments of program costs and benefits.
- Model early childhood programs that deliver carefully designed interventions with well-defined objectives and that include well-designed evaluations have been shown to influence the developmental trajectories of children whose life course is threatened by socioeconomic disadvantage, family disruption, and diagnosed disabilities. Programs that combine child-focused educational activities with explicit attention to parent-child interaction patterns and relationship building appear to have the greatest impacts. In contrast, services that are based on generic family support, often without a clear delineation of intervention strategies matched directly to measurable objectives, and that are funded by more modest budgets, appear to be less effective.
- The elements of early intervention programs that enhance social and emotional development are just as important as the components that enhance linguistic and cognitive competence. Some of the strongest long-term impacts of successful interventions have been documented in the domains of social adjustment, such as reductions in criminal behavior.
- The reconciliation of traditional program formats and strategies— many of which emphasize the importance of active parent involvement and the delivery of services in the home setting—with the economic and social realities of contemporary family life is a pressing concern. Particularly urgent is the need to ensure access to these intervention programs for parents who are employed full-time, those who work nonstandard hours, and those who are making the transition from public assistance to work.
- Early childhood policies and practices are highly fragmented, with complex and confusing points of entry that are particularly problematic for underserved segments of the population and those with special needs. This lack of an integrative early childhood infrastructure makes it difficult to advance prevention-oriented initiatives for all children and to coordinate services for those with complex problems.
- The growing racial, ethnic, linguistic, and cultural diversity of the early childhood population requires that all early childhood programs

and medical services periodically reassess their appropriateness and effectiveness for the wide variety of families they are mandated to serve. Poor "take-up" and high rates of program attrition that are common to many early intervention programs, while not at all restricted to specific racial, ethnic, or linguistic groups, nonetheless raise serious questions about whether those who design, implement, and staff early childhood programs fully understand the meaning of "cultural competence" in the delivery of health and human services.

- The general political environment in which research questions are formulated and investigations are conducted has resulted in a highly problematic context for early childhood policy and practice. In many circumstances, the evaluation of intervention impacts is largely a high-stakes activity to determine whether policies and programs should receive continued funding, rather than a more constructive process of continuous knowledge generation and quality improvement.
- As the rapidly evolving science of early child development continues to grow, its complexity will increase and the distance between the working knowledge of service providers and the cutting edge of the science will be staggering. The professional challenges that this raises for the early childhood field are formidable.

Recommendations

- **Recommendation 9** — Agencies and foundations that support evaluation research in early childhood should follow the example set by the nation's successful approach to clinical investigation in the biomedical sciences. In this spirit, the goals of program-based research and the evaluation of services should be to document and ensure full implementation of effective interventions, and to use evidence of ineffectiveness to stimulate further experimentation and study.
- **Recommendation 10** — The time is long overdue for state and local decision makers to take bold actions to design and implement coordinated, functionally effective infrastructures to reduce the long-standing fragmentation of early childhood policies and programs. To this end, the committee urges two compelling first steps. First, require that all children who are referred to a protective services agency for evaluation of suspected abuse or neglect be automatically referred for a developmental-behavioral screening under Part C of the Individuals With Disabilities Education Act. Second, establish explicit and effective linkages among agencies that currently are charged with implementing the work require

ments of welfare reform and those that oversee the provision of both early intervention programs and child and adult mental health services.

- **Recommendation 11** — A comprehensive analysis of the professional development challenges facing the early childhood field should be conducted as a collaborative effort involving professional organizations and representatives from the wide array of training institutions that prepare people to work with young children and their families. The responsibility for convening such a broad-based working group or commission should be shared among the fields of education, health, and human services.

RESEARCH AND EVALUATION

Research has historically played a significant role in enhancing human development and preventing, ameliorating, and treating a range of conditions that can begin prenatally, at birth, or during the early years of life. To identify priorities among the many possible recommendations that could be made for promising further research, the committee was guided by three goals.

First, it is clear that the capacity to increase the odds of favorable birth outcomes and positive adaptation in the early childhood years would be strengthened considerably by supporting creative collaborations among child development researchers, neuroscientists, and molecular geneticists. Second, there is a pressing need to integrate basic research aimed at understanding developmental processes with intervention research that assesses efforts to influence developmental outcomes. Such collaborative initiatives hold the promise of advancing both understanding of environmental effects on development and improving the effectiveness of the nation's early intervention strategies. Third, the entire early childhood evaluation enterprise warrants a thorough reassessment in order to maximize opportunities for valid causal inference and generalization, to assess what has been learned cumulatively across the full array of evaluation studies, and to establish a constructive environment for discussion of ongoing research and its application to policy. The themes and issues presented below are elaborated in the committee's full complement of research priorities in the full report.

Integrating Child Development Research, Neuroscience, and Molecular Genetics

Enormous potential exists at the intersection of child development research, neuroscience, and molecular and behavioral genetics to unlock some of the enduring mysteries about how biogenetic and environmental factors interact to influence developmental pathways. These include:

(a) understanding how experience is incorporated into the developing nervous system and how the boundaries are determined that differentiate deprivation from sufficiency and sufficiency from enrichment; (b) understanding how biological processes, including neurochemical and neuro-endocrine factors, interact with environmental influences to affect the development of complex behaviors, including self-regulatory capacities, prosocial or antisocial tendencies, planning and sustained attention, and adaptive responses to stress; (c) describing the dynamics of gene-environment interactions that underlie the development of behavior and contribute to differential susceptibility to risk and capacity for resilience; and (d) elucidating the mechanisms that underlie nonoptimal birth outcomes and developmental disabilities.

Integrating the Basic Science of Human Development and the Applied Science of Early Childhood Intervention

There are currently few avenues for integrating knowledge gained from basic developmental science and from evaluations of early interventions. Yet both enterprises ultimately seek to improve children's early outcomes and life opportunities. A great deal stands to be gained from deliberate efforts to forge ongoing interactions among scientists engaged in these complementary yet largely disconnected research traditions. Among the important objectives to be addressed are: (a) enhanced understanding, detection, and treatment of early precursors of psychopathology; (b) improved preventive and ameliorative interventions for women and children who are exposed to biological insults and adverse environmental conditions, as well as for children with identified disabilities; (c) the identification of modifiable mechanisms that link impoverished family resources to both adverse outcomes for individual children and persistent disparities across groups of children in learning skills and other developmental capacities; and (d) refined understanding of how interventions and the staff that implement them can work effectively with families that differ along dimensions defined by race and ethnicity, immigration status, religion, or other cultural characteristics. The capacity of research to address these objectives will hinge in part on investments in improving the available tools for measuring important, but generally neglected early developmental outcomes, such as the multiple components of self-regulatory and executive capacities, and the ability to make friends and engage with others as a contributing member of a group, as well as on increased efforts to evaluate the biological systems that are affected by early interventions.

Improving Evaluations of Early Childhood Interventions

To improve the nation's capacity to learn from evaluations of early childhood interventions, the committee recommends substantially increased attention to program implementation as an integral component of all early childhood evaluation research, the adoption of higher standards for the use of rigorous and appropriate evaluation study designs, the inclusion of early childhood outcomes in evaluations of broad-based community and economic interventions, and the convening of regular forums at the National Institutes of Health to synthesize evaluation research evidence across programs and strategies that share similar developmental aims.

CONCLUDING THOUGHTS

As this report moved to completion, it became increasingly clear to the members of the committee that the science of early childhood development has often been viewed through highly personalized and sharply politicized lenses. In many respects, this is an area in which personal experience allows everyone to claim some level of expertise. Moreover, as a public issue, questions about the care and protection of children confront many of the basic values that have defined our country from its founding—personal responsibility, individual self-reliance, and restrained government involvement in people's lives. In a highly pluralistic society that is experiencing dramatic economic and social change, however, the development of children must be viewed as a matter of intense concern for both their parents and for the nation as a whole.

In this context, and based on the evidence gleaned from a rich and rapidly growing knowledge base, we feel an urgent need to call for a new national dialogue focused on rethinking the meaning of both shared responsibility for children and strategic investment in their future. The time has come to stop blaming parents, communities, business, and government, and to shape a shared agenda to ensure both a rewarding childhood and a promising future for all children.

The charge to this committee was to blend the knowledge and insights of a broad range of disciplines to generate an integrated science of early childhood development. The charge to society is to blend the skepticism of a scientist, the passion of an advocate, the pragmatism of a policy maker, the creativity of a practitioner, and the devotion of a parent—and to use existing knowledge to ensure both a decent quality of life for all of our children and a productive future for the nation.

Eager to Learn

Educating Our Preschoolers

Committee on Early Childhood Pedagogy

Barbara T. Bowman, M. Suzanne Donovan, and M. Susan Burns, *Editors*

Commission on Behavioral and Social Sciences and Education

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Executive Summary

Children come into the world eager to learn. The first five years of life are a time of enormous growth of linguistic, conceptual, social, emotional, and motor competence. Right from birth a healthy child is an active participant in that growth, exploring the environment, learning to communicate, and, in relatively short order, beginning to construct ideas and theories about how things work in the surrounding world. The pace of learning, however, will depend on whether and to what extent the child's inclinations to learn encounter and engage supporting environments. There can be no question that the environment in which a child grows up has a powerful impact on how the child develops and what the child learns.

Eager to Learn: Educating Our Preschoolers is about the education of children ages 2 to 5. It focuses on programs provided outside the home, such as preschool, Head Start, and child care centers. As the twenty-first century begins, there can be little doubt that something approaching voluntary universal early childhood education, a feature of other wealthy industrialized nations, is also on the horizon here. Three major trends have focused public attention on children's education and care in the preschool years:

1. the unprecedented labor force participation of women with young children, which is creating a pressing demand for child care;
2. an emerging consensus among professionals and, to an ever greater

extent, among parents that young children should be provided with educational experiences; and

3. the accumulation of convincing evidence from research that young children are more capable learners than current practices reflect, and that good educational experiences in the preschool years can have a positive impact on school learning.

The growing consensus regarding the importance of early education stands in stark contrast to the disparate system of care and education available to children in the United States in the preschool years. America's programs for preschoolers vary widely in quality, content, organization, sponsorship, source of funding, relationship to the public schools, and government regulation.

Historically, there have been two separate and at times conflicting traditions in the United States that can be encapsulated in the terms *child care* and *preschool.* A central premise of this report, one that grows directly from the research literature, is that *care and education cannot be thought of as separate entities in dealing with young children.* Adequate care involves providing quality cognitive stimulation, rich language environments, and the facilitation of social, emotional, and motor development. Likewise, adequate education for young children can occur only in the context of good physical care and of warm affective relationships. Indeed, research suggests that secure attachment improves social and intellectual competence and the ability to exploit learning opportunities. Neither loving children nor teaching them is, in and of itself, sufficient for optimal development; thinking and feeling work in tandem.

Learning, moreover, is not a matter of simply assimilating a store of facts and skills. Children construct knowledge actively, integrating new concepts and ideas into their existing understandings. Educators have an opportunity and an obligation to facilitate this propensity to learn and to develop a receptivity to learning that will prepare children for active engagement in the learning enterprise throughout their lives. This report argues, therefore, that promoting young children's growth calls for early childhood settings (half day or full day, public or private, child care or preschool) that support the development of the full range of capacities that will serve as a foundation for school learning. As the child is assimilated into the culture of education in a setting outside the home, early childhood programs must be sensitive and responsive to the cultural contexts that define the child's world outside the school or center, and they must build on the strengths and supports that those contexts provide.

CONTEXT OF THE REPORT AND COMMITTEE CHARGE

As Americans grapple with decisions about early childhood education that many European countries have already made, we can draw on certain advantages. We have a strong research community investigating early childhood learning and development and producing evidence on which to base the design, implementation, and evaluation of programs. And we have a tradition of experimentation and observation in preschools that gives us access to a wealth of experience in early childhood education.

The Committee on Early Childhood Pedagogy was established by the National Research Council in 1997 to study a broad range of behavioral and social science research on early learning and development and to explore the implications of that research for the education and care of young children ages 2 to 5. More specifically, the committee was asked to undertake the following:

- Review and synthesize theory, research, and applications in the social, behavioral, and biological sciences that contribute to our understanding of early childhood pedagogy.
- Review the literature and synthesize the research on early childhood pedagogy.
- Review research concerning special populations, such as children living in poverty, children with limited English proficiency, or children with disabilities, and highlight early childhood education practices that enhance the development of these children.
- Produce a coherent distillation of the knowledge base and develop its implications for practice in early childhood education programs, the training of teachers and child care professionals, and future research directions.
- Draw out the major policy implications of the research findings.

The study was carried out at the request of the U.S. Department of Education's Office of Educational Research and Improvement (Early Childhood Institute) and the Office of Special Education Programs, the Spencer Foundation, and the Foundation for Child Development. An important motivation for sponsors of the study is to help public discussion of these issues move away from ideology and toward evidence, so that educators, parents, and policy makers will be able to make better decisions about programs for the education and care of young children.

In accordance with the charge to the committee, this report focuses primarily on research and practice of relevance to programs for young

children that take place outside the home, especially center-based programs. Yet it is important to underscore the point that children's learning and development are strongly influenced by myriad family factors, including parental interaction styles and family aspirations and expectations for achievement. It is also important to note that many of the committee's findings, especially those on children's learning and development, are likely to apply to in-home settings and to parents who care for their own children, and they should also be of interest to family literacy and two-generation programs.

NEW UNDERSTANDINGS OF EARLY CHILDHOOD DEVELOPMENT AND PEDAGOGY

Current conceptions of early childhood development and pedagogy are built on a century of research and experience. Many of the theoretical perspectives that have held sway during that period have been incorporated in some form into early childhood practice. These include the “behaviorist” view of the role of positive reinforcement in behavior and learning, as well as the focus on children's affective-social development—an influence of Freudian theory. A more recent (1970s) influence on preschool practice comes from Piagetian theory, which emphasizes stages of development that are systemically defined. From Piaget's perspective, the emerging capacities of the preschool (or “preoperational”) period involve the development of symbolic abilities: language, imitation, symbolic play, and drawing. While much learning is involved, it takes place in the here and now and focuses largely on the perceptible.

More recent research has led many to reinterpret the stage theorists' views; there is strong evidence that children, when they have accumulated substantial knowledge, have the ability to abstract well beyond what is ordinarily observed. Indeed, the striking feature of modern research is that it describes unexpected competencies in young children, key features of which appear to be universal. These data focus attention on the child's exposure to learning opportunities, calling into question simplistic concep-tualizations of developmentally appropriate practice that do not recognize the newly understood competencies of very young children, and they highlight the importance of individual differences in children, their past experiences, and their present contexts.

Recent research on cognitive development also emphasizes the role a supportive context can play in strengthening and supporting learning in a particular domain. Indeed, techniques that provide a window into the developing brain allow us to see that stimulation from the environment changes the very physiology of the brain, interlocking nature and nurture. Research from a variety of theoretical perspectives suggests that a

defining feature of a supportive environment is a responsible and responsive adult. Parents, teachers, and caregivers promote development when they create learning experiences that build on and extend the child's competence—experiences that are challenging, but within reach. To do so, these adults must be sensitive to individual and developmental characteristics of the child.

VARIATION AMONG CHILDREN

Developmental trends occur in a similar fashion for all children. This does not, however, imply uniformity. On the contrary, individual differences due to genetic and experiential variations and differing cultural and social contexts have strong influences on development. The notion of *lockstepped* development in children is not useful; the potential of human development interacts with diversity among individuals, available resources, and the goals and preferred interaction patterns of communities in a way that links the biological and the social in the construction of diverse developmental pathways.

Children present themselves to preschool teachers or caregivers with many differences in their cognitive, social, physical, and motor skills. These differences are associated with both "functional" characteristics—such as temperament, learning style, and motivation—and "status" characteristics—including gender, race, ethnicity, and social class. Data on children as they enter kindergarten suggest that there are significant differences in many aspects of development by the time children reach the schoolhouse door. Resources (like books and audio recordings) and activities (book reading, story telling, verbal interaction) to which children of higher socioeconomic status (SES) are typically exposed are strong correlates of many aspects of cognitive development, and SES is correlated with social and some forms of physical development as well.

QUALITY IN EDUCATION AND CARE

The issue of quality in early childhood education and care has many dimensions, including political and social dimensions, not all of which lend themselves to research and analysis. Research can, however, inform views of best practice by providing information about the consequences of program features and of curriculum and pedagogy for young children's learning, development, and well-being. A number of distinct, but overlapping, research literatures provide relevant insights. Several decades of research have been conducted on the effects of a wide range of preschool programs on children's learning and development. This research includes experimental comparisons of carefully specified alternative approaches;

experimental and quasi-experimental studies of the effects of "model" programs, Head Start, and public preschool programs on children in poverty; studies relying on "natural variation" among child care programs to examine the effects of program features and quality on the learning and development of children from a broad cross-section of society; studies of programs for English-language learners; and descriptions of exemplary programs in other countries. These literatures provide insight into important components of the quality of preschool programs, one of which is support for cognitive development. Other literatures (including research in cognitive science) focus less on the study of preschool programs and more on the study of children's development and their learning in specific cognitive domains, such as reading, mathematics, and science. These literatures also have implications for curriculum content and pedagogy.

FEATURES OF QUALITY PROGRAMS

There are a number of broadly supported findings regarding components of quality preschool programs:

- ***Cognitive, social-emotional, and motor development are complementary, mutually supportive areas of growth all requiring active attention in the preschool years.*** Social skills and physical dexterity influence cognitive development, just as cognition plays a role in children's social understanding and motor competence. All are therefore related to early learning and later academic achievement and are necessary domains of early childhood pedagogy.
- ***Responsive interpersonal relationships with teachers nurture young children's dispositions to learn and their emerging abilities.*** Social competence and school achievement are influenced by the quality of early teacher-child relationships, and by teachers' attentiveness to how the child approaches learning.
- ***Both class size and adult-child ratios are correlated with greater program effects.*** Low adult-child ratios are associated with more extensive teacher-child interaction, more individualization, and less restrictive and controlling teacher behavior. Smaller group size has been associated with more child initiations, and more opportunities for teachers to work on extending language, mediating children's social interactions, and encouraging and supporting exploration and problem solving.
- ***While no single curriculum or pedagogical approach can be identified as best, children who attend well-planned, high-quality early childhood programs in which curriculum aims are specified and integrated across domains tend to learn more and are better prepared to master the***

complex demands of formal schooling. Particular findings of relevance in this regard include the following:

1. Children who have a broad base of experience in domain-specific knowledge (for example, in mathematics or an area of science) move more rapidly in acquiring more complex skills.
2. More extensive language development—such as a rich vocabulary and listening comprehension—is related to early literacy learning.
3. Children are better prepared for school when early childhood programs expose them to a variety of classroom structures, thought processes, and discourse patterns. This does not mean adopting the methods and curriculum of the elementary school; rather it is a matter of providing children with a mix of whole class, small group, and individual interactions with teachers, the experience of discourse patterns associated with school, and such mental strategies as categorizing, memorizing, reasoning, and metacognition.

- ***Young children who are living in circumstances that place them at greater risk of school failure—including poverty, low level of maternal education, maternal depression, and other factors that can limit their access to opportunities and resources that enhance learning and development—are much more likely to succeed in school if they attend well-planned, high-quality early childhood programs.*** Many children, especially those in low-income households, are served in child care programs of such low quality that learning and development are not enhanced and may even be jeopardized.

  The importance of teacher responsiveness to children's differences, knowledge of children's learning processes and capabilities, and the multiple developmental goals that a quality preschool program must address simultaneously all point to the centrality of teacher education and preparation.
- ***The professional development of teachers is related to the quality of early childhood programs, and program quality predicts developmental outcomes for children.*** Formal early childhood education and training have been linked consistently to positive caregiver behaviors. The strongest relationship is found between the number of years of education and training and the appropriateness of a teacher's classroom behavior.
- ***Programs found to be highly effective in the United States and exemplary programs abroad actively engage teachers and provide high-quality supervision.*** Teachers are trained and encouraged to reflect on

their practice and on the responsiveness of their children to classroom activities, and to revise and plan their teaching accordingly.

CURRICULUM AND PEDAGOGY

Much of the research on young children's learning investigates cognitive development in language, mathematics, and science. Because these appear to be "privileged domains," that is, domains in which children have a natural proclivity to learn, experiment, and explore, they allow for nurturing and extending the boundaries of the learning in which children are already actively engaged. Developing and extending children's interests is particularly important in the preschool years, when attention and self-regulation are nascent abilities.

What should be learned in the preschool curriculum? In addressing this question, the committee focused largely on reading, mathematics, and science because a rich research base has provided insights in these domains suggesting that more can be learned in the preschool years than was previously understood. This does not imply, however, that many of the music, arts and crafts, and physical activities that are common in quality preschool programs are of less importance. Indeed, the committee supports the notion that it is the *whole* child that must be developed. Moreover, these activities—important in their own right—can provide opportunities for developing language, reasoning, and social skills that support learning in more academic areas.

An extensive body of research suggests the types of activity that promote emergent literacy skills. These include story reading and "dialogic reading," providing materials for scribbling and "writing" in pretend play, participating in classroom conversation, and identifying letters and words. In mathematics and science, research indicates that children are capable of thinking that is both complex and abstract. Curricula that work with children's emergent understandings and provide the concepts, knowledge, and opportunities to extend those understandings, have been used effectively in the preschool years. When these activities operate in the child's "zone of proximal development," where learning is within reach but takes the child just beyond his or her existing ability, these curricula have been reported to be both enjoyable and educational.

While the committee does not endorse any particular curriculum, the cognitive science literature suggests principles of learning that should be incorporated into any curriculum:

- Teaching and learning will be most effective if they engage and build on children's existing understandings.
- Key concepts involved in each domain of preschool learning (e.g.,

representational systems in early literacy, the concept of quantity in mathematics, causation in the physical world) must go hand in hand with information and skill acquisition (e.g., identifying numbers and letters and acquiring information about the natural world).

- Metacognitive skill development allows children to learn to solve problems more effectively. Curricula that encourage children to reflect, predict, question, and hypothesize (examples: How many will there be after two numbers are added? What happens next in the story? Will it sink or float?) set them on course for effective, engaged learning.

How should teaching be done in preschool? Research indicates that many teaching strategies *can* work. Good teachers acknowledge and encourage children's efforts, model and demonstrate, create challenges and support children in extending their capabilities, and provide specific directions or instruction. All of these teaching strategies can be used in the context of play and structured activities. Effective teachers also organize the classroom environment and plan ways to pursue educational goals for each child as opportunities arise in child-initiated activities and in activities planned and initiated by the teacher.

This panoply of strategies provides a tool kit from which the teacher can select the right tool for the right task at the right time. Children need opportunities to initiate activities and follow their interests, but teachers are not passive during these initiated and directed activities. Similarly, children should be actively engaged and responsive during teacher-initiated and directed activities. Good teachers help support the child's learning in both types of activities. They also recognize that children learn from each other and from interactions with the physical environment. Since preschool programs serve so many ends simultaneously, multiple pedagogical approaches should be expected.

ASSESSMENT IN EARLY CHILDHOOD EDUCATION

If the trend of increasing enrollments in early childhood education programs continues in this country, the use of assessments and tests as instruments of education policy and practice is also likely to increase. There is great potential in the use of assessment to support learning. The importance of building new learning on prior knowledge, the episodic course of development in any given child, and the enormous variability among children in background and development all mean that assessment and instruction are inseparable parts of effective pedagogy. What preschool teachers do to guide and promote learning needs to be based on what each child brings to the interaction, cognitively, culturally, and

developmentally. Careful assessment is even more critical to effective strategies for working with children with disabilities and special needs.

The growing sense of public responsibility for the quality of early childhood programs means that there are also external pressures to use tests and assessments for program evaluation and monitoring and for school accountability. Such high-stakes uses of assessment data for purposes external to the classroom increase the requirement for measurement validity and heighten the need for caution in interpreting results.

All assessments, and particularly assessments for accountability, must be used carefully and appropriately if they are to resolve, and not create, educational problems. Assessment of young children poses greater challenges than people generally realize. The first five years of life are a time of incredible growth and learning, but the course of development is uneven and sporadic. The status of a child's development as of any given day can change very rapidly. Consequently, assessment results—in particular, standardized test scores that reflect a given point in time—can easily misrepresent children's learning.

Few early childhood teachers or administrators are trained to understand traditional standardized tests and measurements. As a consequence, misuse is rampant, as experience with readiness tests demonstrates. Likewise, early childhood personnel are seldom offered real preparation in the development and use of alternative assessments.

Assessment itself is in a state of flux. There is widespread dissatisfaction with traditional norm-referenced standardized tests, which are based on early 20th century psychological theory. There are a number of promising new approaches to assessment, among them variations on the clinical interview and performance assessment, but the field must be described as emergent. Much more research and development are needed for a productive fusion of assessment and instruction to occur and if the potential benefits of assessment for accountability are to be fully realized.

RECOMMENDATIONS

What is now known about the potential of the early years, and of the promise of high-quality preschool programs to help realize that potential for all children, stands in stark contrast to practice in many—perhaps most—early childhood settings. In the committee's view, bringing what is known to bear on what is done in early childhood education will require efforts in four areas: (1) professional development of teachers; (2) development of teaching materials that reflect research-based understandings of children's learning; (3) development of public policies that support—through standards and appropriate assessment, regulations, and funding—the provision of quality preschool experiences; and (4) efforts

to make more recent understandings of development in the preschool years common public knowledge. The committee proposes recommendations in each of these areas.

Professional Development

At the heart of the effort to promote quality early childhood programs, from the committee's perspective, is a substantial investment in the education and training of those who work with young children.

Recommendation 1: Each group of children in an early childhood education and care program should be assigned a teacher who has a bachelor's degree with specialized education related to early childhood (e.g., developmental psychology, early childhood education, early childhood special education). Achieving this goal will require a significant public investment in the professional development of current and new teachers.

Sadly, there is a great disjunction between what is optimal pedagogically for children's learning and development and the level of preparation that currently typifies early childhood educators. Progress toward a high-quality teaching force will require substantial public and private support and incentive systems, including innovative educational programs, scholarship and loan programs, and compensation commensurate with the expectations of college graduates.

Recommendation 2: Education programs for teachers should provide them with a stronger and more specific foundational knowledge of the development of children's social and affective behavior, thinking, and language.

Few programs currently do. This foundation should be linked to teachers' knowledge of mathematics, science, linguistics, literature, etc., as well as to instructional practices for young children.

Recommendation 3: Teacher education programs should require mastery of information on the pedagogy of teaching preschool-aged children, including:

- Knowledge of teaching and learning and child development and how to integrate them into practice.
- Information about how to provide rich conceptual experiences that promote growth in specific content areas, as well as particular areas of development, such as language (vocabulary) and cognition (reasoning).
- Knowledge of effective teaching strategies, including organizing

the environment and routines so as to promote activities that build social-emotional relationships in the classroom.

- Knowledge of subject-matter content appropriate for preschool children and knowledge of professional standards in specific content areas.
- Knowledge of assessment procedures (observation/performance records, work sampling, interview methods) that can be used to inform instruction.
- Knowledge of the variability among children, in terms of teaching methods and strategies that may be required, including teaching children who do not speak English, children from various economic and regional contexts, and children with identified disabilities.
- Ability to work with teams of professionals.
- Appreciation of the parents' role and knowledge of methods of collaboration with parents and families.
- Appreciation of the need for appropriate strategies for accountability.

Recommendation 4: A critical component of preservice preparation should be a supervised, relevant student teaching or internship experience in which new teachers receive ongoing guidance and feedback from a qualified supervisor.

There are a number of models (e.g., National Council for Accreditation of Teacher Education) that suggest the value of this sort of supervised student teaching experience.

Recommendation 5: All early childhood education and child care programs should have access to a qualified supervisor of early childhood education.

Teachers should be provided with opportunities to reflect on practice with qualified supervisors.

Recommendation 6: Federal and state departments of education, human services, and other agencies interested in young children and their families should initiate programs of research and development aimed at learning more about effective preparation of early childhood teachers.

Recommendation 7: The committee recommends the development of demonstration schools for professional development.

The U.S. Department of Education should collaborate with universities in developing the demonstration schools and in using them as sites for ongoing research:

- on the efficacy of various models, including pairing demonstration schools as partners with community programs, and pairing researchers and in-service teachers with exemplary community-based programs;
- to identify conditions under which the gains of mentoring, placement of preservice teachers in demonstration schools, and supervised student teaching can be sustained once teachers move into community-based programs.

Educational Materials

Recommendation 8: The committee recommends that the U.S. Department of Education, the U.S. Department of Health and Human Services, and their equivalents at the state level fund efforts to develop, design, field test, and evaluate curricula that incorporate what is known about learning and thinking in the early years, with companion assessment tools and teacher guides.

Each curriculum should emphasize what is known from research about children's thinking and learning in the area it addresses. Activities should be included that enable children with different learning styles and strengths to learn.

Each curriculum should include a companion guide for teachers that explains the teaching goals, alerts the teacher to common misconceptions, and suggests ways in which the curriculum can be used flexibly for students at different developmental levels. In the teacher's guide, the description of methods of assessment should be linked to instructional planning so that the information acquired in the process of assessment can be used as a basis for making pedagogical decisions at the level of both the group and the individual child.

Recommendation 9: The committee recommends that the U.S. Department of Education and the U.S. Department of Health and Human Services support the use of effective technology, including videodiscs for preschool teachers and Internet communication groups.

The process of early childhood education is one in which interaction between the adult/teacher and the child/student is the most critical feature. Opportunities to see curriculum and pedagogy in action are likely to promote understanding of complexity and nuance not easily communicated in the written word. Internet communication groups could provide information on curricula, results of field tests, and opportunities for teachers using a common curriculum to discuss experiences, query each other, and share ideas.

Policy

States can play a significant role in promoting program quality with respect to both teacher preparation and curriculum and pedagogy.

Recommendation 10: All states should develop *program* standards for early childhood programs and monitor their implementation.

These standards should recognize the variability in the development of young children and adapt kindergarten and primary programs, as well as preschool programs, to this diversity. This means, for instance, that kindergartens must be readied for children. In some schools, this will require smaller class sizes and professional development for teachers and administrators regarding appropriate teaching practice, so that teachers can meet the needs of individual children, rather than teaching to the "average" child. The standards should outline essential components and should include, but not be limited to, the following categories:

- School-home relationships,
- Class size and teacher-student ratios,
- Specification of pedagogical goals, content, and methods,
- Assessment for instructional improvement,
- Educational requirements for early childhood educators, and
- Monitoring quality/external accountability.

Recommendation 11: Because research has identified content that is appropriate and important for inclusion in early childhood programs, *content* standards should be developed and evaluated regularly to ascertain whether they adhere to current scientific understanding of children's learning.

The content standards should ensure that children have access to rich and varied opportunities to learn in areas that are now omitted from many curricula —such as phonological awareness, number concepts, methods of scientific investigation, cultural knowledge, and language.

Recommendation 12: A single career ladder for early childhood teachers, with differentiated pay levels, should be specified by each state.

This career ladder should include, at a minimum, teaching assistants (with child development associate certification), teachers (with bachelor's degrees), and supervisors.

Recommendation 13: The committee recommends that the federal government fund well-planned, high-quality center-based preschool programs for all children at high risk of school failure.

Such programs can prevent school failure and significantly enhance learning and development in ways that benefit the entire society.

The Public

Recommendation 14: Organizations and government bodies concerned with the education of young children should actively promote public understanding of early childhood education and care.

Beliefs that are at odds with scientific understanding—that maturation automatically accounts for learning, for example, or that children can learn concrete skills only through drill and practice—must be challenged. Systematic and widespread public education should be undertaken to increase public awareness of the importance of providing stimulating educational experiences in the lives of all young children. The message that the quality of children's relationships with adult teachers and child care providers is critical in preparation for elementary school should be featured prominently in communication efforts. Parents and other caregivers, as well as the public, should be the targets of such efforts.

Recommendation 15: Early childhood programs and centers should build alliances with parents to cultivate complementary and mutually reinforcing environments for young children at home and at the center.

FUTURE RESEARCH NEEDS

Research on child development and education can and has influenced the development of early childhood curriculum and pedagogy. But the influences are mutual. By evaluating outcomes of early childhood programs we have come to understand more about children's development and capacities. The committee believes that continued research efforts along both these lines can expand understanding of early childhood education and care, and the ability to influence them for the better.

Research on Early Childhood Learning and Development

Although it is apparent that early experiences affect later ones, there are a number of important developmental questions to be studied regard

ing how, when, and which early experiences support development and learning.

Recommendation 16: The committee recommends a broad empirical research program to better understand:

- The range of inputs that can contribute to supporting environments that nurture young children's eagerness to learn;
- Development of children's capacities in the variety of cognitive and socioemotional areas of importance in the preschool years, and the contexts that enhance that development;
- The components of adult-child relationships that enhance the child's development during the preschool years, and experiences affecting that development for good or for ill;
- Variation in brain development, and its implications for sensory processing, attention, and regulation, are particularly relevant;
- The implications of developmental disabilities for learning and development and effective approaches for working with children who have disabilities;
- With regard to children whose home language is not English, the age and level of native language mastery that is desirable before a second language is introduced and the trajectory of second language development.

Research on Programs, Curricula, and Assessment

Recommendation 17: The next generation of research must examine more rigorously the characteristics of programs that produce beneficial outcomes for all children. In addition, research is needed on how programs can provide more helpful structures, curricula, and methods for children at high risk of educational difficulties, including children from low-income homes and communities, children whose home language is not English, and children with developmental and learning disabilities.

Research on programs for any population of children should examine such program variations as age groupings, adult-child ratios, curricula, class size, and program duration. These questions can best be answered through longitudinal studies employing random assignment. In developing and assessing curricula, new research must also continue to consider the interplay between an individual child's characteristics, the immediate

contexts of the home and classroom, and the larger contexts of the formal school environment.

Recommendation 18: A broad program of research and development should be undertaken to advance the state of the art of assessment in three areas: (1) classroom-based assessment to support learning (including studies of the impact of methods of instructional assessment on pedagogical technique and children's learning); (2) assessment for diagnostic purposes; and (3) assessment of program quality for accountability and other reasons of public policy.

Research on Ways to Create Universal High Quality

Recommendation 19: Research to fully develop and evaluate alternatives for organizing, regulating, supporting, and financing early childhood programs should be conducted to provide an empirical base for the decisions being made.

The current early childhood system is fragmented, lacks uniform standards, and provides uneven access to all children. Numerous policy choices have been proposed. This research would inform public policy decision making.

CONCLUSION

At a time when the importance of education to individual fulfillment and economic success has focused attention on the need to better prepare children for academic achievement, the research literature suggests ways to make gains toward that end. Parents are relying on child care and preschool programs in ever larger numbers. We know that the quality of the programs in which they leave their children matters. If there is a single critical component to quality, it rests in the relationship between the child and the teacher/caregiver, and in the ability of the adult to be responsive to the child. But responsiveness extends in many directions: to the child's cognitive, social, emotional, and physical characteristics and development.

Much research still needs to be done. But from the committee's perspective, the case for a substantial investment in a high-quality system of child care and preschool on the basis of what is already known is persuasive. Moreover, the considerable lead by other developed countries in the provision of quality preschool programs suggests that it can, indeed, be done on a large scale.

Preventing Reading Difficulties in Young Children

Catherine E. Snow, M. Susan Burns, and Peg Griffin, *Editors*

Committee on the Prevention of Reading Difficulties in Young Children

Commission on Behavioral and Social Sciences and Education

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COMMITTEE ON THE PREVENTION OF READING DIFFICULTIES IN YOUNG CHILDREN

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Executive Summary

Reading is essential to success in our society. The ability to read is highly valued and important for social and economic advancement. Of course, most children learn to read fairly well. In this report, we are most concerned with the large numbers of children in America whose educational careers are imperiled because they do not read well enough to ensure understanding and to meet the demands of an increasingly competitive economy. Current difficulties in reading largely originate from rising demands for literacy, not from declining absolute levels of literacy. In a technological society, the demands for higher literacy are ever increasing, creating more grievous consequences for those who fall short.

The importance of this problem led the U.S. Department of Education and the U.S. Department of Health and Human Services to ask the National Academy of Sciences to establish a committee to examine the prevention of reading difficulties. Our committee was charged with conducting a study of the effectiveness of interventions for young children who are at risk of having problems learning to read. The goals of the project were three: (1) to comprehend a rich but diverse research base; (2) to translate the research findings into advice and guidance for parents, educators, publishers, and others involved in the care and instruction of the young; and (3) to convey this advice to the targeted audiences through a variety of publications, conferences, and other outreach activities.

THE COMMITTEE'S APPROACH

The committee reviewed research on normal reading development and instruction; on risk factors useful in identifying groups and individuals at risk of reading failure; and on prevention, intervention, and instructional approaches to ensuring optimal reading outcomes.

We found many informative literatures to draw on and have aimed in this report to weave together the insights of many research traditions into clear guidelines for helping children become successful readers. In doing so, we also considered the current state of affairs in education for teachers and others working with young children; policies of federal, state, and local governments impinging on young children's education; the pressures on publishers of curriculum materials, texts, and tests; programs addressed to parents and to community action; and media activities.

Our main emphasis has been on the development of reading and on factors that relate to reading outcomes. We conceptualized our task as cutting through the detail of mostly convergent, but sometimes discrepant, research findings to provide an integrated picture of how reading develops and how its development can be promoted.

Our recommendations extend to all children. Granted, we have focused our lens on children at risk for learning to read. But much of the instructional research we have reviewed encompasses, for a variety of reasons, populations of students with varying degrees of risk. Good instruction seems to transcend characterizations of children's vulnerability for failure; the same good early literacy environment and patterns of effective instruction are required for children who might fail for different reasons.

Does this mean that the identical mix of instructional materials and strategies will work for each and every child? Of course not. If we have learned anything from this effort, it is that effective teachers are able to craft a special mix of instructional ingredients for every child they work with. But it does mean that there is a common menu of materials, strategies, and environments from which effective teachers make choices. This in turn means that, as a society, our most important challenge is to make sure that our teachers have access to those tools and the knowledge required to use them well. In other words, there is little evidence that children experiencing difficulties learning to read, even those with identifiable learning disabilities, need radically different sorts of supports than children at low risk, although they may need much more intensive support. Childhood environments that support early literacy development and excellent instruction are important for all children. Excellent instruction is the best intervention for children who demonstrate problems learning to read.

CONCEPTUALIZING READING AND READING INSTRUCTION

Effective reading instruction is built on a foundation that recognizes that reading ability is determined by multiple factors: many factors that correlate with reading fail to explain it; many experiences contribute to reading development without being prerequisite to it; and although there are many prerequisites, none by itself is considered sufficient.

Adequate initial reading instruction requires that children:

- use reading to obtain meaning from print,
- have frequent and intensive opportunities to read,
- be exposed to frequent, regular spelling-sound relationships,
- learn about the nature of the alphabetic writing system, and
- understand the structure of spoken words.

Adequate progress in learning to read English (or any alphabetic language) beyond the initial level depends on:

- having a working understanding of how sounds are represented alphabetically,
- sufficient practice in reading to achieve fluency with different kinds of texts,
- sufficient background knowledge and vocabulary to render written texts meaningful and interesting,
- control over procedures for monitoring comprehension and repairing misunderstandings, and
- continued interest and motivation to read for a variety of purposes.

Reading skill is acquired in a relatively predictable way by children who have normal or above-average language skills; have had experiences in early childhood that fostered motivation and provided exposure to literacy in use; get information about the nature of print through opportunities to learn letters and to recognize the internal structure of spoken words, as well as explanations about the contrasting nature of spoken and written language; and attend schools that provide effective reading instruction and opportunities to practice reading.

Disruption of any of these developments increases the possibility that reading will be delayed or impeded. The association of poor reading outcomes with poverty and minority status no doubt reflects the accumulated effects of several of these risk factors, including lack of access to literacy-stimulating preschool experiences and to excellent, coherent reading instruction. In addition, a number of children without any obvious risk factors also develop reading difficulties. These children may require

intensive efforts at intervention and extra help in reading and accommodations for their disability throughout their lives.

There are three potential stumbling blocks that are known to throw children off course on the journey to skilled reading. The first obstacle, which arises at the outset of reading acquisition, is difficulty understanding and using the alphabetic principle—the idea that written spellings systematically represent spoken words. It is hard to comprehend connected text if word recognition is inaccurate or laborious. The second obstacle is a failure to transfer the comprehension skills of spoken language to reading and to acquire new strategies that may be specifically needed for reading. The third obstacle to reading will magnify the first two: the absence or loss of an initial motivation to read or failure to develop a mature appreciation of the rewards of reading.

As in every domain of learning, motivation is crucial. Although most children begin school with positive attitudes and expectations for success, by the end of the primary grades and increasingly thereafter, some children become disaffected. The majority of reading problems faced by today's adolescents and adults are the result of problems that might have been avoided or resolved in their early childhood years. It is imperative that steps be taken to ensure that children overcome these obstacles during the primary grades.

Reducing the number of children who enter school with inadequate literacy-related knowledge and skill is an important primary step toward preventing reading difficulties. Although not a panacea, this would serve to reduce considerably the magnitude of the problem currently facing schools. Children who are particularly likely to have difficulty with learning to read in the primary grades are those who begin school with less prior knowledge and skill in relevant domains, most notably general verbal abilities, the ability to attend to the sounds of language as distinct from its meaning, familiarity with the basic purposes and mechanisms of reading, and letter knowledge. Children from poor neighborhoods, children with limited proficiency in English, children with hearing impairments, children with preschool language impairments, and children whose parents had difficulty learning to read are particularly at risk of arriving at school with weaknesses in these areas and hence of falling behind from the outset.

RECOMMENDATIONS

The critical importance of providing excellent reading instruction to all children is at the heart of the committee's recommendations. Accordingly, our central recommendation characterizes the nature of good primary reading instruction. We also recognize that excellent instruction is

most effective when children arrive in first grade motivated for literacy and with the necessary linguistic, cognitive, and early literacy skills. We therefore recommend attention to ensuring high-quality preschool and kindergarten environments as well. We acknowledge that excellent instruction in the primary grades and optimal environments in preschool and kindergarten require teachers who are well prepared, highly knowledgeable, and receiving ongoing support. Excellent instruction may be possible only if schools are organized in optimal ways; if facilities, curriculum materials, and support services function adequately; and if children's home languages are taken into account in designing instruction. We therefore make recommendations addressing these issues. (The complete text of all the committee's recommendations appears in Chapter 10 [of the full report].)

Literacy Instruction in First Through Third Grades

Given the centrality of excellent instruction to the prevention of reading difficulties, the committee strongly recommends attention in every primary-grade classroom to the full array of early reading accomplishments: the alphabetic principle, reading sight words, reading words by mapping speech sounds to parts of words, achieving fluency, and comprehension. Getting started in alphabetic reading depends critically on mapping the letters and spellings of words onto the speech units that they represent; failure to master word recognition can impede text comprehension. Explicit instruction that directs children's attention to the sound structure of oral language and to the connections between speech sounds and spellings assists children who have not grasped the alphabetic principle or who do not apply it productively when they encounter unfamiliar printed words.

Comprehension difficulties can be prevented by actively building comprehension skills as well as linguistic and conceptual knowledge, beginning in the earliest grades. Comprehension can be enhanced through instruction focused on concept and vocabulary growth and background knowledge, instruction about the syntax and rhetorical structures of written language, and direct instruction about comprehension strategies such as summarizing, predicting, and monitoring. Comprehension also takes practice, which is gained by reading independently, by reading in pairs or groups, and by being read aloud to.

We recommend that first through third grade curricula include the following components:

- Beginning readers need explicit instruction and practice that lead to an appreciation that spoken words are made up of smaller units of

sounds, familiarity with spelling-sound correspondences and common spelling conventions and their use in identifying printed words, "sight" recognition of frequent words, and independent reading, including reading aloud. Fluency should be promoted through practice with a wide variety of well-written and engaging texts at the child's own comfortable reading level.

- Children who have started to read independently, typically second graders and above, should be encouraged to sound out and confirm the identities of visually unfamiliar words they encounter in the course of reading meaningful texts, recognizing words primarily through attention to their letter-sound relationships. Although context and pictures can be used as a tool to monitor word recognition, children should not be taught to use them to substitute for information provided by the letters in the word.
- Because the ability to obtain meaning from print depends so strongly on the development of word recognition accuracy and reading fluency, both of the latter should be regularly assessed in the classroom, permitting timely and effective instructional response when difficulty or delay is apparent.
- Beginning in the earliest grades, instruction should promote comprehension by actively building linguistic and conceptual knowledge in a rich variety of domains, as well as through direct instruction about comprehension strategies such as summarizing the main idea, predicting events and outcomes of upcoming text, drawing inferences, and monitoring for coherence and misunderstandings. This instruction can take place while adults read to students or when students read themselves.
- Once children learn some letters, they should be encouraged to write them, to use them to begin writing words or parts of words, and to use words to begin writing sentences. Instruction should be designed with the understanding that the use of invented spelling is not in conflict with teaching correct spelling. Beginning writing with invented spelling can be helpful for developing understanding of the identity and segmentation of speech sounds and sound-spelling relationships. Conventionally correct spelling should be developed through focused instruction and practice. Primary-grade children should be expected to spell previously studied words and spelling patterns correctly in their final writing products. Writing should take place regularly and frequently to encourage children to become more comfortable and familiar with it.
- Throughout the early grades, time, materials, and resources should be provided with two goals: (a) to support daily independent reading of texts selected to be of particular interest for the individual student, and beneath the individual student's frustration level, in order to consolidate the student's capacity for independent reading and (b) to support daily

assisted or supported reading and rereading of texts that are slightly more difficult in wording or in linguistic, rhetorical, or conceptual structure in order to promote advances in the student's capabilities.

- Throughout the early grades, schools should promote independent reading outside school by such means as daily at-home reading assignments and expectations, summer reading lists, encouraging parent involvement, and by working with community groups, including public librarians, who share this goal.

Promoting Literacy Development in Preschool and Kindergarten

It is clear from the research that the process of learning to read is a lengthy one that begins very early in life. Given the importance identified in the research literature of starting school motivated to read and with the prerequisite language and early literacy skills, the committee recommends that all children, especially those at risk for reading difficulties, should have access to early childhood environments that promote language and literacy growth and that address a variety of skills that have been identified as predictors of later reading achievement. Preschools and other group care settings for young children often provide relatively impoverished language and literacy environments, in particular those available to families with limited economic resources. As ever more young children are entering group care settings pursuant to expectations that their mothers will join the work force, it becomes critical that the preschool opportunities available to lower-income families be designed in ways that support language and literacy development.

Preschool programs, even those designed specifically as interventions for children at risk of reading difficulties, should be designed to provide optimal support for cognitive, language, and social development, within this broad focus. However, ample attention should be paid to skills that are known to predict future reading achievement, especially those for which a causal role has been demonstrated. Similarly, and for the same reasons, kindergarten instruction should be designed to stimulate verbal interaction; to enrich children's vocabularies; to encourage talk about books; to provide practice with the sound structure of words; to develop knowledge about print, including the production and recognition of letters; and to generate familiarity with the basic purposes and mechanisms of reading.

Children who will probably need additional support for early language and literacy development should receive it as early as possible. Pediatricians, social workers, speech-language therapists, and other preschool practitioners should receive research-based guidelines to assist them to be alert for signs that children are having difficulties acquiring

early language and literacy skills. Parents, relatives, neighbors, and friends can also play a role in identifying children who need assistance. Through adult education programs, public service media, instructional videos provided by pediatricians, and other means, parents can be informed about what skills and knowledge children should be acquiring at young ages, and about what to do and where to turn if there is concern that a child's development may be lagging behind in some respects.

Education and Professional Development for All Involved in Literacy Instruction

The critical importance of the teacher in the prevention of reading difficulties must be recognized, and efforts should be made to provide all teachers with adequate knowledge about reading and the knowledge and skill to teach reading or its developmental precursors. It is imperative that teachers at all grade levels understand the course of literacy development and the role of instruction in optimizing literacy development.

Preschool teachers represent an important, and largely underutilized, resource in promoting literacy by supporting rich language and emergent literacy skills. Early childhood educators should not try to replicate the formal reading instruction provided in schools.

The preschool and primary school teacher's knowledge and experience, as well as the support provided to the teacher, are central to achieving the goal of primary prevention of reading difficulties. Each of these may vary according to where the teacher is in his or her professional development. A critical component in the preparation of pre-service teachers is supervised, relevant, clinical experience providing ongoing guidance and feedback, so they develop the ability to integrate and apply their knowledge in practice.

Teachers need to be knowledgeable about the research foundations of reading. Collaborative support by the teacher preparation institution and the field placement is essential. A critical component for novice teachers is the support of mentors who have demonstrated records of success in teaching reading.

Professional development should not be conceived as something that ends with graduation from a teacher preparation program, nor as something that happens primarily in graduate classrooms or even during inservice activities. Rather, ongoing support from colleagues and specialists, as well as regular opportunities for self-examination and reflection, are critical components of the career-long development of excellent teachers.

Teaching Reading to Speakers of Other Languages

Schools have the responsibility to accommodate the linguistic needs of students with limited proficiency in English. Precisely how to do this is difficult to prescribe, because students' abilities and needs vary greatly, as do the capacities of different communities to support their literacy development. The committee recommends the following guidelines for decision making:

- If language-minority children arrive at school with no proficiency in English but speaking a language for which there are instructional guides, learning materials, and locally available proficient teachers, these children should be taught how to read in their native language while acquiring proficiency in spoken English and then subsequently taught to extend their skills to reading in English.
- If language-minority children arrive at school with no proficiency in English but speak a language for which the above conditions cannot be met and for which there are insufficient numbers of children to justify the development of the local capacity to meet such conditions, the instructional priority should be to develop the children's proficiency in spoken English. Although print materials may be used to develop understanding of English speech sounds, vocabulary, and syntax, the postponement of formal reading instruction is appropriate until an adequate level of proficiency in spoken English has been achieved.

Ensuring Adequate Resources to Meet Children's Needs

To be effective, schools with large numbers of children at risk for reading difficulties need rich resources—manageable class sizes and student-teacher ratios, high-quality instructional materials in sufficient quantity, good school libraries, and pleasant physical environments. Achieving this may require extra resources for schools that serve a disproportionate number of high-risk children.

Even in schools in which a large percentage of the students are not achieving at a satisfactory level, a well-designed classroom reading program, delivered by an experienced and competent teacher, may be successful in bringing most students to grade level or above during the primary grades. However, achieving and sustaining radical gains is often difficult when improvements are introduced on a classroom-by-classroom basis. In a situation of school-wide poor performance, school restructuring should be considered as a vehicle for preventing reading difficulties. Ongoing professional development for teachers is typically a component of successful school restructuring efforts.

Addressing the Needs of Children with Persistent Reading Difficulties

Even with excellent instruction in the early grades, some children fail to make satisfactory progress in reading. Such children will require supplementary services, ideally from a reading specialist who provides individual or small-group intensive instruction that is coordinated with high-quality instruction from the classroom teacher. Children who are having difficulty learning to read do not, as a rule, require qualitatively different instruction from children who are "getting it." Instead, they more often need application of the same principles by someone who can apply them expertly to individual children who are having difficulty for one reason or another.

Schools that lack or have abandoned reading specialist positions need to reexamine their needs for such specialists to ensure that well-trained staff are available for intervention with children and for ongoing support to classroom teachers. Reading specialists and other specialist roles need to be defined so that two-way communication is required between specialists and classroom teachers about the needs of all children at risk of or experiencing reading difficulties. Coordination is needed at the instructional level so that intervention from specialists coordinates with and supports classroom instruction. Schools that have reading specialists as well as special educators need to coordinate the roles of these specialists. Schools need to ensure that all the specialists engaged in child study or individualized educational program (IEP) meetings for special education placement, early childhood intervention, out-of-classroom interventions, or in-classroom support are well informed about research in reading development and the prevention of reading difficulties.

Although volunteer tutors can provide valuable practice and motivational support for children learning to read, they should not be expected either to provide primary reading instruction or to instruct children with serious reading problems.

CONCLUSION

Most reading difficulties can be prevented. There is much work to be done, however, that requires the aggressive deployment of the information currently available, which is distilled in [the full] report. In addition, many questions remain unanswered concerning reading development, some of which we address in our recommendations for research. While science continues to discover more about how children learn to read and how teachers and others can help them, the knowledge currently available can equip our society to promote higher levels of literacy for large numbers of American schoolchildren. The committee's hope is that the recommendations contained in this report will provide direction for the first important steps.

How People Learn Brain, Mind, Experience, and School

Expanded Edition

Committee on Developments in the Science of Learning

John D. Bransford, Ann L. Brown, and Rodney R. Cocking, editors with additional material from the Committee on Learning Research and Educational Practice

M. Suzanne Donovan, John D. Bransford, and James W. Pellegrino, *editors*

Commission on Behavioral and Social Sciences and Education

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COMMITTEE ON LEARNING RESEARCH AND EDUCATIONAL PRACTICE

Learning: From Speculation to Science

The essence of matter, the origins of the universe, the nature of the human mind—these are the profound questions that have engaged thinkers through the centuries. Until quite recently, understanding the mind— and the thinking and learning that the mind makes possible—has remained an elusive quest, in part because of a lack of powerful research tools. Today, the world is in the midst of an extraordinary outpouring of scientific work on the mind and brain, on the processes of thinking and learning, on the neural processes that occur during thought and learning, and on the development of competence.

The revolution in the study of the mind that has occurred in the last three or four decades has important implications for education. As we illustrate, a new theory of learning is coming into focus that leads to very different approaches to the design of curriculum, teaching, and assessment than those often found in schools today. Equally important, the growth of interdisciplinary inquiries and new kinds of scientific collaborations have begun to make the path from basic research to educational practice somewhat more visible, if not yet easy to travel. Thirty years ago, educators paid little attention to the work of cognitive scientists, and researchers in the nascent field of cognitive science worked far removed from classrooms. Today, cognitive researchers are spending more time working with teachers, testing and refining their theories in real class

Note: References are not included in this booklet but are available online at *www.nap.edu.* Search under title of report.

rooms where they can see how different settings and classroom interactions influence applications of their theories.

What is perhaps currently most striking is the variety of research approaches and techniques that have been developed and ways in which evidence from many different branches of science are beginning to converge. The story we can now tell about learning is far richer than ever before, and it promises to evolve dramatically in the next generation. For example:

- Research from cognitive psychology has increased understanding of the nature of competent performance and the principles of knowledge organization that underlie people's abilities to solve problems in a wide variety of areas, including mathematics, science, literature, social studies, and history.
- Developmental researchers have shown that young children understand a great deal about basic principles of biology and physical causality, about number, narrative, and personal intent, and that these capabilities make it possible to create innovative curricula that introduce important concepts for advanced reasoning at early ages.
- Research on learning and transfer has uncovered important principles for structuring learning experiences that enable people to use what they have learned in new settings.
- Work in social psychology, cognitive psychology, and anthropology is making clear that all learning takes place in settings that have particular sets of cultural and social norms and expectations and that these settings influence learning and transfer in powerful ways.
- Neuroscience is beginning to provide evidence for many principles of learning that have emerged from laboratory research, and it is showing how learning changes the physical structure of the brain and, with it, the functional organization of the brain.
- Collaborative studies of the design and evaluation of learning environments, among cognitive and developmental psychologists and educators, are yielding new knowledge about the nature of learning and teaching as it takes place in a variety of settings. In addition, researchers are discovering ways to learn from the “wisdom of practice” that comes from successful teachers who can share their expertise.
- Emerging technologies are leading to the development of many new opportunities to guide and enhance learning that were unimagined even a few years ago.

All of these developments in the study of learning have led to an era of new relevance of science to practice. In short, investment in basic research is paying off in practical applications. These developments in under

standing of how humans learn have particular significance in light of changes in what is expected of the nation's educational systems.

In the early part of the twentieth century, education focused on the acquisition of literacy skills: simple reading, writing, and calculating. It was not the general rule for educational systems to train people to think and read critically, to express themselves clearly and persuasively, to solve complex problems in science and mathematics. Now, at the end of the century, these aspects of high literacy are required of almost everyone in order to successfully negotiate the complexities of contemporary life. The skill demands for work have increased dramatically, as has the need for organizations and workers to change in response to competitive workplace pressures. Thoughtful participation in the democratic process has also become increasingly complicated as the locus of attention has shifted from local to national and global concerns.

Above all, information and knowledge are growing at a far more rapid rate than ever before in the history of humankind. As Nobel laureate Herbert Simon wisely stated, the meaning of “knowing” has shifted from being able to remember and repeat information to being able to find and use it (Simon, 1996). More than ever, the sheer magnitude of human knowledge renders its coverage by education an impossibility; rather, the goal of education is better conceived as helping students develop the intellectual tools and learning strategies needed to acquire the knowledge that allows people to think productively about history, science and technology, social phenomena, mathematics, and the arts. Fundamental understanding about subjects, including how to frame and ask meaningful questions about various subject areas, contributes to individuals' more basic understanding of principles of learning that can assist them in becoming self-sustaining, lifelong learners.

FOCUS: PEOPLE, SCHOOLS, AND THE POTENTIAL TO LEARN

The scientific literatures on cognition, learning, development, culture, and brain are voluminous. Three organizing decisions, made fairly early in the work of the committee, provided the framework for our study.

- First, we focus primarily on research on human learning (though the study of animal learning provides important collateral information), including new developments from neuroscience.
- Second, we focus especially on learning research that has implications for the design of formal instructional environments, primarily pre-schools, kindergarten through high schools (K-12), and colleges.
- Third, and related to the second point, we focus on research that helps explore the possibility of helping all individuals achieve their fullest potential.

New ideas about ways to facilitate learning—and about who is most capable of learning—can powerfully affect the quality of people's lives. At different points in history, scholars have worried that formal educational environments have been better at selecting talent than developing it (see, e.g., Bloom, 1964). Many people who had difficulty in school might have prospered if the new ideas about effective instructional practices had been available. Furthermore, given new instructional practices, even those who did well in traditional educational environments might have developed skills, knowledge, and attitudes that would have significantly enhanced their achievements.

Learning research suggests that there are new ways to introduce students to traditional subjects, such as mathematics, science, history and literature, and that these new approaches make it possible for the majority of individuals to develop a deep understanding of important subject matter. This committee is especially interested in theories and data that are relevant to the development of new ways to introduce students to such traditional subjects as mathematics, science, history, and literature. There is hope that new approaches can make it possible for a majority of individuals to develop a moderate to deep understanding of important subjects.

DEVELOPMENT OF THE SCIENCE OF LEARNING

This report builds on research that began in the latter part of the nineteenth century—the time in history at which systematic attempts were made to study the human mind through scientific methods. Before then, such study was the province of philosophy and theology. Some of the most influential early work was done in Leipzig in the laboratory of Wilhelm Wundt, who with his colleagues tried to subject human consciousness to precise analysis—mainly by asking subjects to reflect on their thought processes through introspection.

By the turn of the century, a new school of behaviorism was emerging. In reaction to the subjectivity inherent in introspection, behaviorists held that the scientific study of psychology must restrict itself to the study of observable behaviors and the stimulus conditions that control them. An extremely influential article, published by John B. Watson in 1913, provides a glimpse of the behaviorist credo:

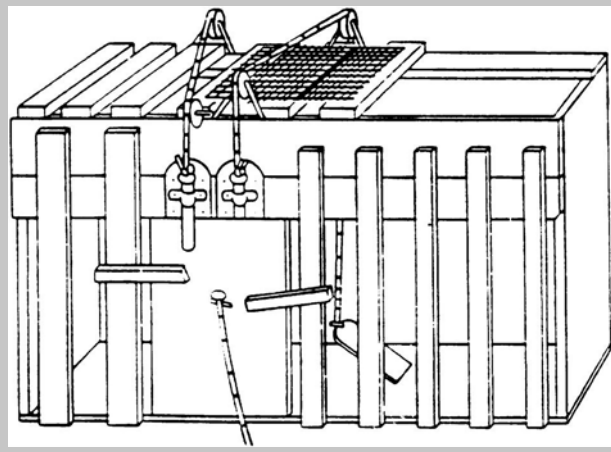
> . . . all schools of psychology except that of behaviorism claim that "consciousness" is the subject-matter of psychology. Behaviorism, on the contrary, holds that the subject matter of human psychology is the behavior or activities of the human being. Behaviorism claims that "consciousness" is neither a definable nor a useable concept; that it is merely another word for the "soul" of more ancient times. The old psychology is thus dominated by a kind of subtle religious philosophy (p. 1).

Drawing on the empiricist tradition, behaviorists conceptualized learning as a process of forming connections between stimuli and responses. Motivation to learn was assumed to be driven primarily by drives, such as hunger, and the availability of external forces, such as rewards and punishments (e.g., Thorndike, 1913; Skinner, 1950).

In a classic behaviorist study by Edward L. Thorndike (1913), hungry cats had to learn to pull a string hanging in a "puzzle box" in order for a door to open that let them escape and get food. What was involved in learning to escape in this manner? Thorndike concluded that the cats did not think about how to escape and then do it; instead, they engaged in trial-and-error behavior; see Box 1.1. Sometimes a cat in the puzzle box

BOX 1.1

A CAT'S LEARNING



"When put into the box, the cat would show evident signs of discomfort and impulse to escape from confinement. It tries to squeeze through any opening; it claws and bites at the wire; it thrusts its paws out through any opening and claws at everything it reaches. . . . It does not pay very much attention to the food outside but seems simply to strive instinctively to escape from confinement. . . . The cat that is clawing all over the box in her impulsive struggle will probably claw the string or loop or button so as to open the door. And gradually all the other unsuccessful impulses will be stamped out and the particular impulse leading to the successful act will be stamped in by the resulting pleasure, until, after many trials, the cat will, when put in the box, immediately claw the button or loop in a definite way" (Thorndike, 1913:13).

accidentally pulled the strings while playing and the door opened, allowing the cat to escape. But this event did not appear to produce an insight on the part of the cat because, when placed in the puzzle box again, the cat did not immediately pull the string to escape. Instead, it took a number of trials for the cats to learn through trial and error. Thorndike argued that rewards (e.g., food) increased the strength of connections between stimuli and responses. The explanation of what appeared to be complex problem-solving phenomena as escaping from a complicated puzzle box could thus be explained without recourse to unobservable mental events, such as thinking.

A limitation of early behaviorism stemmed from its focus on observable stimulus conditions and the behaviors associated with those conditions. This orientation made it difficult to study such phenomena as understanding, reasoning, and thinking—phenomena that are of paramount importance for education. Over time, radical behaviorism (often called "Behaviorism with a Capital B") gave way to a more moderate form of behaviorism ("behaviorism with a small b") that preserved the scientific rigor of using behavior as data, but also allowed hypotheses about internal "mental" states when these became necessary to explain various phenomena (e.g., Hull, 1943; Spence, 1942).

In the late 1950s, the complexity of understanding humans and their environments became increasingly apparent, and a new field emerged—cognitive science. From its inception, cognitive science approached learning from a multidisciplinary perspective that included anthropology, linguistics, philosophy, developmental psychology, computer science, neuroscience, and several branches of psychology (Norman, 1980,1993; Newell and Simon, 1972). New experimental tools, methodologies, and ways of postulating theories made it possible for scientists to begin serious study of mental functioning: to test their theories rather than simply speculate about thinking and learning (see, e.g., Anderson, 1982, 1987; deGroot, 1965,1969; Newell and Simon, 1972; Ericsson and Charness, 1994), and, in recent years, to develop insights into the importance of the social and cultural contexts of learning (e.g., Cole, 1996; Lave, 1988; Lave and Wenger, 1991; Rogoff, 1990; Rogoff et al., 1993). The introduction of rigorous qualitative research methodologies have provided perspectives on learning that complement and enrich the experimental research traditions (Erickson, 1986; Hammersly and Atkinson, 1983; Heath, 1982; Lincoln and Guba, 1985; Marshall and Rossman, 1955; Miles and Huberman, 1984; Spradley, 1979).

Learning with Understanding

One of the hallmarks of the new science of learning is its emphasis on learning with understanding. Intuitively, understanding is good, but it

has been difficult to study from a scientific perspective. At the same time, students often have limited opportunities to understand or make sense of topics because many curricula have emphasized memory rather than understanding. Textbooks are filled with facts that students are expected to memorize, and most tests assess students' abilities to remember the facts. When studying about veins and arteries, for example, students may be expected to remember that arteries are thicker than veins, more elastic, and carry blood from the heart; veins carry blood back to the heart. A test item for this information may look like the following:

1. Arteries

a. Are more elastic than veins
b. Carry blood that is pumped from the heart
c. Are less elastic than veins
d. Both a and b
e. Both b and c

The new science of learning does not deny that facts are important for thinking and problem solving. Research on expertise in areas such as chess, history, science, and mathematics demonstrate that experts' abilities to think and solve problems depend strongly on a rich body of knowledge about subject matter (e.g., Chase and Simon, 1973; Chi et al., 1981; deGroot, 1965). However, the research also shows clearly that “usable knowledge” is not the same as a mere list of disconnected facts. Experts' knowledge is connected and organized around important concepts (e.g., Newton's second law of motion); it is “conditionalized” to specify the contexts in which it is applicable; it supports understanding and transfer (to other contexts) rather than only the ability to remember.

For example, people who are knowledgeable about veins and arteries know more than the facts noted above: they also understand why veins and arteries have particular properties. They know that blood pumped from the heart exits in spurts and that the elasticity of the arteries helps accommodate pressure changes. They know that blood from the heart needs to move upward (to the brain) as well as downward and that the elasticity of an artery permits it to function as a one-way valve that closes at the end of each spurt and prevents the blood from flowing backward. Because they understand relationships between the structure and function of veins and arteries, knowledgeable individuals are more likely to be able to use what they have learned to solve novel problems—to show evidence of transfer. For example, imagine being asked to design an artificial artery—would it have to be elastic? Why or why not? An understanding of reasons for the properties of arteries suggests that elasticity may not be necessary—perhaps the problem can be solved by creating a

conduit that is strong enough to handle the pressure of spurts from the heart and also function as a one-way valve. An understanding of veins and arteries does not guarantee an answer to this design question, but it does support thinking about alternatives that are not readily available if one only memorizes facts (Bransford and Stein, 1993).

Pre-Existing Knowledge

An emphasis on understanding leads to one of the primary characteristics of the new science of learning: its focus on the processes of knowing (e.g., Piaget, 1978; Vygotsky, 1978). Humans are viewed as goal-directed agents who actively seek information. They come to formal education with a range of prior knowledge, skills, beliefs, and concepts that significantly influence what they notice about the environment and how they organize and interpret it. This, in turn, affects their abilities to remember, reason, solve problems, and acquire new knowledge.

Even young infants are active learners who bring a point of view to the learning setting. The world they enter is not a "booming, buzzing confusion" (James, 1890), where every stimulus is equally salient. Instead, an infant's brain gives precedence to certain kinds of information: language, basic concepts of number, physical properties, and the movement of animate and inanimate objects. In the most general sense, the contemporary view of learning is that people construct new knowledge and understandings based on what they already know and believe (e.g., Cobb, 1994; Piaget, 1952, 1973a,b, 1977, 1978; Vygotsky, 1962, 1978). A classic children's book illustrates this point; see Box 1.2 .

BOX 1.2

FISH IS FISH

Fish Is Fish (Lionni, 1970) describes a fish who is keenly interested in learning about what happens on land, but the fish cannot explore land because it can only breathe in water. It befriends a tadpole who grows into a frog and eventually goes out onto the land. The frog returns to the pond a few weeks later and reports on what he has seen. The frog describes all kinds of things like birds, cows, and people. The book shows pictures of the fish's representations of each of these descriptions: each is a fish-like form that is slightly adapted to accommodate the frog's descriptions—people are imagined to be fish who walk on their tailfins, birds are fish with wings, cows are fish with udders. This tale illustrates both the creative opportunities and dangers inherent in the fact that people construct new knowledge based on their current knowledge.

A logical extension of the view that new knowledge must be constructed from existing knowledge is that teachers need to pay attention to the incomplete understandings, the false beliefs, and the naive renditions of concepts that learners bring with them to a given subject. Teachers then need to build on these ideas in ways that help each student achieve a more mature understanding. If students' initial ideas and beliefs are ignored, the understandings that they develop can be very different from what the teacher intends.

Consider the challenge of working with children who believe that the earth is flat and attempting to help them understand that it is spherical. When told it is round, children picture the earth as a pancake rather than as a sphere (Vosniadou and Brewer, 1989). If they are then told that it is round like a sphere, they interpret the new information about a spherical earth within their flat-earth view by picturing a pancake-like flat surface inside or on top of a sphere, with humans standing on top of the pancake. The children's construction of their new understandings has been guided by a model of the earth that helped them explain how they could stand or walk upon its surface, and a spherical earth did not fit their mental model. Like *Fish Is Fish,* everything the children heard was incorporated into that pre-existing view.

Fish Is Fish is relevant not only for young children, but for learners of all ages. For example, college students often have developed beliefs about physical and biological phenomena that fit their experiences but do not fit scientific accounts of these phenomena. These preconceptions must be addressed in order for them to change their beliefs (e.g., Confrey, 1990; Mestre, 1994; Minstrell, 1989; Redish, 1996).

A common misconception regarding “constructivist” theories of knowing (that existing knowledge is used to build new knowledge) is that teachers should never tell students anything directly but, instead, should always allow them to construct knowledge for themselves. This perspective confuses a theory of pedagogy (teaching) with a theory of knowing. Constructivists assume that all knowledge is constructed from previous knowledge, irrespective of how one is taught (e.g., Cobb, 1994)— even listening to a lecture involves active attempts to construct new knowledge. *Fish Is Fish* (Lionni, 1970) and attempts to teach children that the earth is round (Vosniadou and Brewer, 1989) show why simply providing lectures frequently does not work. Nevertheless, there are times, usually after people have first grappled with issues on their own, that “teaching by telling” can work extremely well (e.g., Schwartz and Bransford, 1998). However, teachers still need to pay attention to students' interpretations and provide guidance when necessary.

There is a good deal of evidence that learning is enhanced when teachers pay attention to the knowledge and beliefs that learners bring to

a learning task, use this knowledge as a starting point for new instruction, and monitor students' changing conceptions as instruction proceeds. For example, sixth graders in a suburban school who were given inquirybased physics instruction were shown to do better on conceptual physics problems than eleventh and twelfth grade physics students taught by conventional methods in the same school system. A second study comparing seventh-ninth grade urban students with the eleventh and twelfth grade suburban physics students again showed that the younger students, taught by the inquiry-based approach, had a better grasp of the fundamental principles of physics (White and Frederickson, 1997, 1998). New curricula for young children have also demonstrated results that are extremely promising: for example, a new approach to teaching geometry helped second-grade children learn to represent and visualize three-dimensional forms in ways that exceeded the skills of a comparison group of undergraduate students at a leading university (Lehrer and Chazan, 1998). Similarly, young children have been taught to demonstrate powerful forms of early geometry generalizations (Lehrer and Chazan, 1998) and generalizations about science (Schauble et al., 1995; Warren and Rosebery, 1996).

Active Learning

New developments in the science of learning also emphasize the importance of helping people take control of their own learning. Since understanding is viewed as important, people must learn to recognize when they understand and when they need more information. What strategies might they use to assess whether they understand someone else's meaning? What kinds of evidence do they need in order to believe particular claims? How can they build their own theories of phenomena and test them effectively?

Many important activities that support active learning have been studied under the heading of “metacognition,” a topic discussed in more detail in Chapters 2 and 3 [of the full report]. Metacognition refers to people's abilities to predict their performances on various tasks (e.g., how well they will be able to remember various stimuli) and to monitor their current levels of mastery and understanding (e.g., Brown, 1975; Flavell, 1973). Teaching practices congruent with a metacognitive approach to learning include those that focus on sense-making, self-assessment, and reflection on what worked and what needs improving. These practices have been shown to increase the degree to which students transfer their learning to new settings and events (e.g., Palincsar and Brown, 1984; Scardamalia et al., 1984; Schoenfeld, 1983, 1985, 1991).

Imagine three teachers whose practices affect whether students learn

to take control of their own learning (Scardamalia and Bereiter, 1991). Teacher A's goal is to get the students to produce work; this is accomplished by supervising and overseeing the quantity and quality of the work done by the students. The focus is on activities, which could be anything from old-style workbook activities to the trendiest of space-age projects. Teacher B assumes responsibility for what the students are learning as they carry out their activities. Teacher C does this as well, but with the added objective of continually turning more of the learning process over to the students. Walking into a classroom, you cannot immediately tell these three kinds of teachers apart. One of the things you might see is the students working in groups to produce videos or multimedia presentations. The teacher is likely to be found going from group to group, checking how things are going and responding to requests. Over the course of a few days, however, differences between Teacher A and Teacher B would become evident. Teacher A's focus is entirely on the production process and its products —whether the students are engaged, whether everyone is getting fair treatment, and whether they are turning out good pieces of work. Teacher B attends to all of this as well, but Teacher B is also attending to what the students are learning from the experience and is taking steps to ensure that the students are processing content and not just dealing with show. To see a difference between Teachers B and C, however, you might need to go back into the history of the media production project. What brought it about in the first place? Was it conceived from the start as a learning activity, or did it emerge from the students' own knowledge building efforts? In one striking example of a Teacher C classroom, the students had been studying cockroaches and had learned so much from their reading and observation that they wanted to share it with the rest of the school; the production of a video came about to achieve that purpose (Lamon et al., 1997).

The differences in what might seem to be the same learning activity are thus quite profound. In Teacher A's classroom, the students are learning something of media production, but the media production may very well be getting in the way of learning anything else. In Teacher B's classroom, the teacher is working to ensure that the original educational purposes of the activity are met, that it does not deteriorate into a mere media production exercise. In Teacher C's classroom, the media production is continuous with and a direct outgrowth of the learning that is embodied in the media production. The greater part of Teacher C's work has been done before the idea of a media production even comes up, and it remains only to help the students keep sight of their purposes as they carry out the project.

These hypothetical teachers—A, B, and C—are abstract models that of course fit real teachers only partly, and more on some days than others.

Nevertheless, they provide important glimpses of connections between goals for learning and teaching practices that can affect students' abilities to accomplish these goals.

Implications for Education

Overall, the new science of learning is beginning to provide knowledge to improve significantly people's abilities to become active learners who seek to understand complex subject matter and are better prepared to transfer what they have learned to new problems and settings. Making this happen is a major challenge (e.g., Elmore et al., 1996), but it is not impossible. The emerging science of learning underscores the importance of rethinking what is taught, how it is taught, and how learning is assessed. These ideas are developed throughout [the full report].

An Evolving Science

This volume synthesizes the scientific basis of learning. The scientific achievements include a fuller understanding of: (1) memory and the structure of knowledge; (2) problem solving and reasoning; (3) the early foundations of learning; (4) regulatory processes that govern learning, including metacognition; and (5) how symbolic thinking emerges from the culture and community of the learner.

These key characteristics of learned proficiency by no means plumb the depths of human cognition and learning. What has been learned about the principles that guide some aspects of learning do not constitute a complete picture of the principles that govern all domains of learning. The scientific bases, while not superficial in themselves, do represent only a surface level of a complete understanding of the subject. Only a few domains of learning have been examined in depth, as reflected in this book, and new, emergent areas, such as interactive technologies (Greenfield and Cocking, 1996) are challenging generalizations from older research studies.

As scientists continue to study learning, new research procedures and methodologies are emerging that are likely to alter current theoretical conceptions of learning, such as computational modeling research. The scientific work encompasses a broad range of cognitive and neuroscience issues in learning, memory, language, and cognitive development. Studies of parallel distributed processing, for example (McClelland et al., 1995; Plaut et al., 1996; Munakata et al., 1997; McClelland and Chappell, 1998) look at learning as occurring through the adaptation of connections among participating neurons. The research is designed to develop explicit computational models to refine and extend basic principles, as well as to

apply the models to substantive research questions through behavioral experiments, computer simulations, functional brain imaging, and mathematical analyses. These studies are thus contributing to modification of both theory and practice. New models also encompass learning in adulthood to add an important dimension to the scientific knowledge base.

Key Findings

This report provides a broad overview of research on learners and learning and on teachers and teaching. Three findings are highlighted here because they have both a solid research base to support them and strong implications for how we teach.

1. **Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.**

Research on early learning suggests that the process of making sense of the world begins at a very young age. Children begin in preschool years to develop sophisticated understandings (whether accurate or not) of the phenomena around them (Wellman, 1990). Those initial understandings can have a powerful effect on the integration of new concepts and information. Sometimes those understandings are accurate, providing a foundation for building new knowledge. But sometimes they are inaccurate (Carey and Gelman, 1991). In science, students often have misconceptions of physical properties that cannot be easily observed. In humanities, their preconceptions often include stereotypes or simplifications, as when history is understood as a struggle between good guys and bad guys (Gardner, 1991). A critical feature of effective teaching is that it elicits from students their preexisting understanding of the subject matter to be taught and provides opportunities to build on—or challenge—the initial understanding. James Minstrell, a high school physics teacher, describes the process as follows (Minstrell, 1989: 130-131):

> Students' initial ideas about mechanics are like strands of yarn, some unconnected, some loosely interwoven. The act of instruction can be viewed as helping the students unravel individual strands of belief, label them, and then weave them into a fabric of more complete understanding. Rather than denying the relevancy of a belief, teachers might do better by helping students differentiate their present ideas from and integrate them into conceptual beliefs more like those of scientists.

The understandings that children bring to the classroom can already be quite powerful in the early grades. For example, some children have been found to hold onto their preconception of a flat earth by imagining a round earth to be shaped like a pancake (Vosniadou and Brewer, 1989). This construction of a new understanding is guided by a model of the earth that helps the child explain how people can stand or walk on its surface. Many young children have trouble giving up the notion that one-eighth is greater than one-fourth, because 8 is more than 4 (Gelman and Gallistel, 1978). If children were blank slates, telling them that the earth is round or that one-fourth is greater than one-eighth would be adequate. But since they already have ideas about the earth and about numbers, those ideas must be directly addressed in order to transform or expand them.

Drawing out and working with existing understandings is important for learners of all ages. Numerous research experiments demonstrate the persistence of preexisting understandings among older students even after a new model has been taught that contradicts the naïve understanding. For example, in a study of physics students from elite, technologically oriented colleges, Andrea DiSessa (1982) instructed them to play a computerized game that required them to direct a computer-simulated object called a dynaturtle so that it would hit a target and do so with minimum speed at impact. Participants were introduced to the game and given a hands-on trial that allowed them to apply a few taps with a small wooden mallet to a tennis ball on a table before beginning the game. The same game was also played by elementary schoolchildren. DiSessa found that both groups of students failed dismally. Success would have required demonstrating an understanding of Newton's laws of motion. Despite their training, college physics students, like the elementary school-children, aimed the moving dynaturtle directly at the target, failing to take momentum into account. Further investigation of one college student who participated in the study revealed that she knew the relevant physical properties and formulas, yet, in the context of the game, she fell back on her untrained conception of how the physical world works.

Students at a variety of ages persist in their beliefs that seasons are caused by the earth's distance from the sun rather than by the tilt of the earth (Harvard-Smithsonian Center for Astrophysics, 1987), or that an object that had been tossed in the air has both the force of gravity and the force of the hand that tossed it acting on it, despite training to the contrary (Clement, 1982). For the scientific understanding to replace the naïve understanding, students must reveal the latter and have the opportunity to see where it falls short.

2. To develop competence in an area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts

and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.

This principle emerges from research that compares the performance of experts and novices and from research on learning and transfer. Experts, regardless of the field, always draw on a richly structured information base; they are not just "good thinkers" or "smart people." The ability to plan a task, to notice patterns, to generate reasonable arguments and explanations, and to draw analogies to other problems are all more closely intertwined with factual knowledge than was once believed.

But knowledge of a large set of disconnected facts is not sufficient. To develop competence in an area of inquiry, students must have opportunities to learn with understanding. Deep understanding of subject matter transforms factual information into usable knowledge. A pronounced difference between experts and novices is that experts' command of concepts shapes their understanding of new information: it allows them to see patterns, relationships, or discrepancies that are not apparent to novices. They do not necessarily have better overall memories than other people. But their conceptual understanding allows them to extract a level of meaning from information that is not apparent to novices, and this helps them select and remember relevant information. Experts are also able to fluently access relevant knowledge because their understanding of subject matter allows them to quickly identify what is relevant. Hence, their attention is not overtaxed by complex events.

In most areas of study in K-12 education, students will begin as novices; they will have informal ideas about the subject of study, and will vary in the amount of information they have acquired. The enterprise of education can be viewed as moving students in the direction of more formal understanding (or greater expertise). This will require both a deepening of the information base and the development of a conceptual framework for that subject matter.

Geography can be used to illustrate the manner in which expertise is organized around principles that support understanding. A student can learn to fill in a map by memorizing states, cities, countries, etc., and can complete the task with a high level of accuracy. But if the boundaries are removed, the problem becomes much more difficult. There are no concepts supporting the student's information. An expert who understands that borders often developed because natural phenomena (like mountains or water bodies) separated people, and that large cities often arose in locations that allowed for trade (along rivers, large lakes, and at coastal ports) will easily outperform the novice. The more developed the conceptual understanding of the needs of cities and the resource base that drew people to them, the more meaningful the map becomes. Students can

become more expert if the geographical information they are taught is placed in the appropriate conceptual framework.

BOX 1.3

THROWING DARTS UNDER WATER

In one of the most famous early studies comparing the effects of learning a procedure with learning with understanding, two groups of children practiced throwing darts at a target under water (described in Judd, 1908; see a conceptual replication by Hendrickson and Schroeder, 1941). One group received an explanation of the refraction of light, which causes the apparent location of the target to be deceptive. The other group only practiced dart throwing, without the explanation. Both groups did equally well on the practice task, which involved a target 12 inches under water. But the group that had been instructed about the abstract principle did much better when they had to transfer to a situation in which the target was under only 4 inches of water. Because they understood what they were doing, the group that had received instruction about the refraction of light could adjust their behavior to the new task.

A key finding in the learning and transfer literature is that organizing information into a conceptual framework allows for greater "transfer"; that is, it allows the student to apply what was learned in new situations and to learn related information more quickly (see Box 1.3). The student who has learned geographical information for the Americas in a conceptual framework approaches the task of learning the geography of another part of the globe with questions, ideas, and expectations that help guide acquisition of the new information. Understanding the geographical importance of the Mississippi River sets the stage for the student's understanding of the geographical importance of the Nile. And as concepts are reinforced, the student will transfer learning beyond the classroom, observing and inquiring, for example, about the geographic features of a visited city that help explain its location and size (Holyoak, 1984; Novick and Holyoak, 1991).

3. **A "metacognitive" approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.**

In research with experts who were asked to verbalize their thinking as they worked, it was revealed that they monitored their own understanding carefully, making note of when additional information was required for understanding, whether new information was consistent with

what they already knew, and what analogies could be drawn that would advance their understanding. These meta-cognitive monitoring activities are an important component of what is called adaptive expertise (Hatano and Inagaki, 1986).

Because metacognition often takes the form of an internal conversation, it can easily be assumed that individuals will develop the internal dialogue on their own. Yet many of the strategies we use for thinking reflect cultural norms and methods of inquiry (Hutchins, 1995; Brice-Heath, 1981, 1983; Suina and Smolkin, 1994). Research has demonstrated that children can be taught these strategies, including the ability to predict outcomes, explain to oneself in order to improve understanding, note failures to comprehend, activate background knowledge, plan ahead, and apportion time and memory. Reciprocal teaching, for example, is a technique designed to improve students' reading comprehension by helping them explicate, elaborate, and monitor their understanding as they read (Palincsar and Brown, 1984). The model for using the meta-cognitive strategies is provided initially by the teacher, and students practice and discuss the strategies as they learn to use them. Ultimately, students are able to prompt themselves and monitor their own comprehension without teacher support.

The teaching of metacognitive activities must be incorporated into the subject matter that students are learning (White and Frederickson, 1998). These strategies are not generic across subjects, and attempts to teach them as generic can lead to failure to transfer. Teaching metacognitive strategies in context has been shown to improve understanding in physics (White and Frederickson, 1998), written composition (Scardamalia et al., 1984), and heuristic methods for mathematical problem solving (Schoenfeld, 1983, 1984, 1991). And metacognitive practices have been shown to increase the degree to which students transfer to new settings and events (Lin and Lehman, in press; Palincsar and Brown, 1984; Scardamalia et al., 1984; Schoenfeld, 1983, 1984, 1991).

Each of these techniques shares a strategy of teaching and modeling the process of generating alternative approaches (to developing an idea in writing or a strategy for problem solving in mathematics), evaluating their merits in helping to attain a goal, and monitoring progress toward that goal. Class discussions are used to support skill development, with a goal of independence and self-regulation.

Implications for Teaching

The three core learning principles described above, simple though they seem, have profound implications for the enterprise of teaching and teacher preparation.

1. **Teachers must draw out and work with the preexisting understandings that their students bring with them.** This requires that:
    - The model of the child as an empty vessel to be filled with knowledge provided by the teacher must be replaced. Instead, the teacher must actively inquire into students' thinking, creating classroom tasks and conditions under which student thinking can be revealed. Students' initial conceptions then provide the foundation on which the more formal understanding of the subject matter is built.
    - The roles for assessment must be expanded beyond the traditional concept of testing. The use of frequent formative assessment helps make students' thinking visible to themselves, their peers, and their teacher. This provides feedback that can guide modification and refinement in thinking. Given the goal of learning with understanding, assessments must tap understanding rather than merely the ability to repeat facts or perform isolated skills.
    - Schools of education must provide beginning teachers with opportunities to learn: (a) to recognize predictable preconceptions of students that make the mastery of particular subject matter challenging, (b) to draw out preconceptions that are not predictable, and (c) to work with preconceptions so that children build on them, challenge them and, when appropriate, replace them.
2. **Teachers must teach some subject matter in depth, providing many examples in which the same concept is at work and providing a firm foundation of factual knowledge.** This requires that:
    - Superficial coverage of all topics in a subject area must be replaced with in-depth coverage of fewer topics that allows key concepts in that discipline to be understood. The goal of coverage need not be abandoned entirely, of course. But there must be a sufficient number of cases of indepth study to allow students to grasp the defining concepts in specific domains within a discipline. Moreover, in-depth study in a domain often requires that ideas be carried beyond a single school year before students can make the transition from informal to formal ideas. This will require active coordination of the curriculum across school years.
    - Teachers must come to teaching with the experience of in-depth study of the subject area themselves. Before a teacher can develop powerful pedagogical tools, he or she must be familiar with the progress of inquiry and the terms of discourse in the discipline, as well as understand the relationship between information and the concepts that help organize that information in the discipline. But equally important, the teacher must have a grasp of the growth and development of students' thinking

about these concepts. The latter will be essential to developing teaching expertise, but not expertise in the discipline. It may therefore require courses, or course supplements, that are designed specifically for teachers.

- Assessment for purposes of accountability (e.g., statewide assessments) must test deep understanding rather than surface knowledge. Assessment tools are often the standard by which teachers are held accountable. A teacher is put in a bind if she or he is asked to teach for deep conceptual understanding, but in doing so produces students who perform more poorly on standardized tests. Unless new assessment tools are aligned with new approaches to teaching, the latter are unlikely to muster support among the schools and their constituent parents. This goal is as important as it is difficult to achieve. The format of standardized tests can encourage measurement of factual knowledge rather than conceptual understanding, but it also facilitates objective scoring. Measuring depth of understanding can pose challenges for objectivity. Much work needs to be done to minimize the trade-off between assessing depth and assessing objectively.

3. **The teaching of metacognitive skills should be integrated into the curriculum in a variety of subject areas.** Because metacognition often takes the form of an internal dialogue, many students may be unaware of its importance unless the processes are explicitly emphasized by teachers. An emphasis on metacognition needs to accompany instruction in each of the disciplines, because the type of monitoring required will vary. In history, for example, the student might be asking himself, "who wrote this document, and how does that affect the interpretation of events," whereas in physics the student might be monitoring her understanding of the underlying physical principle at work.

    - Integration of metacognitive instruction with discipline-based learning can enhance student achievement and develop in students the ability to learn independently. It should be consciously incorporated into curricula across disciplines and age levels.
    - Developing strong metacognitive strategies and learning to teach those strategies in a classroom environment should be standard features of the curriculum in schools of education.

Evidence from research indicates that when these three principles are incorporated into teaching, student achievement improves. For example, the Thinker Tools Curriculum for teaching physics in an interactive computer environment focuses on fundamental physical concepts and properties, allowing students to test their preconceptions in model building and experimentation activities. The program includes an "inquiry

cycle" that helps students monitor where they are in the inquiry process. The program asks for students' reflective assessments and allows them to review the assessments of their fellow students. In one study, sixth graders in a suburban school who were taught physics using Thinker Tools performed better at solving conceptual physics problems than did eleventh and twelfth grade physics students in the same school system taught by conventional methods. A second study comparing urban students in grades 7 to 9 with suburban students in grades 11 and 12 again showed that the younger students taught by the inquiry-based approach had a superior grasp of the fundamental principles of physics (White and Frederickson, 1997, 1998).

Bringing Order to Chaos

A benefit of focusing on how people learn is that it helps bring order to a seeming cacophony of choices. Consider the many possible teaching strategies that are debated in education circles and the media. Figure 1.1 depicts them in diagram format: lecture-based teaching, text-based teaching, inquiry-based teaching, technology-enhanced teaching, teaching organized around individuals versus cooperative groups, and so forth. Are some of these teaching techniques better than others? Is lecturing a poor way to teach, as many seem to claim? Is cooperative learning effective? Do attempts to use computers (technology-enhanced teaching) help achievement or hurt it?

This report suggests that these are the wrong questions. Asking which teaching technique is best is analogous to asking which tool is best—a hammer, a screwdriver, a knife, or pliers. In teaching as in carpentry, the selection of tools depends on the task at hand and the materials one is working with. Books and lectures *can* be wonderfully efficient modes of transmitting new information for learning, exciting the imagination, and honing students' critical faculties—but one would choose other kinds of activities to elicit from students their preconceptions and level of understanding, or to help them see the power of using meta-cognitive strategies to monitor their learning. Hands-on experiments *can* be a powerful way to ground emergent knowledge, but they do not alone evoke the underlying conceptual understandings that aid generalization. There is no universal best teaching practice.

If, instead, the point of departure is a core set of learning principles, then the selection of teaching strategies (mediated, of course, by subject matter, grade level, and desired outcome) can be purposeful. The many possibilities then become a rich set of opportunities from which a teacher constructs an instructional program rather than a chaos of competing alternatives.

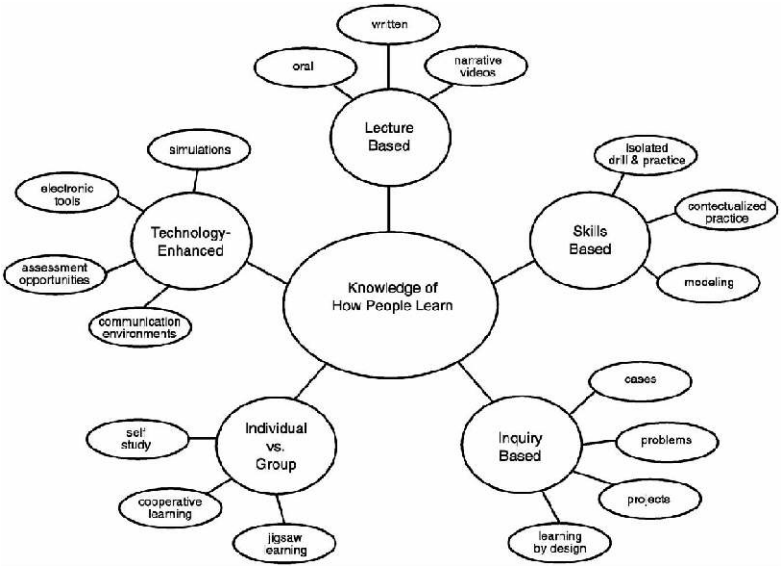


FIGURE 1.1 With knowledge of how people learn, teachers can choose more purposefully among techniques to accomplish specific goals.

Focusing on how people learn also will help teachers move beyond either-or dichotomies that have plagued the field of education. One such issue is whether schools should emphasize “the basics” or teach thinking and problem-solving skills. This volume shows that both are necessary. Students' abilities to acquire organized sets of facts and skills are actually enhanced when they are connected to meaningful problem-solving activities, and when students are helped to understand why, when, and how those facts and skills are relevant. And attempts to teach thinking skills without a strong base of factual knowledge do not promote problem-solving ability or support transfer to new situations.

Designing Classroom Environments

Chapter 6 [of the full report] proposes a framework to help guide the design and evaluation of environments that can optimize learning. Drawing heavily on the three principles discussed above, it posits four interrelated attributes of learning environments that need cultivation.

1. **Schools and classrooms must be learner centered.** Teachers must pay close attention to the knowledge, skills, and attitudes that learners bring into the classroom. This incorporates the preconceptions regarding subject matter already discussed, but it also includes a broader understanding of the learner. For example:

    - Cultural differences can affect students' comfort level in working collaboratively versus individually, and they are reflected in the background knowledge students bring to a new learning situation (Moll et al., 1993).
    - Students' theories of what it means to be intelligent can affect their performance. Research shows that students who think that intelligence is a fixed entity are more likely to be performance oriented than learning oriented—they want to look good rather than risk making mistakes while learning. These students are especially likely to bail out when tasks become difficult. In contrast, students who think that intelligence is malleable are more willing to struggle with challenging tasks; they are more comfortable with risk (Dweck, 1989; Dweck and Legget, 1988).
    - Teachers in learner-centered classrooms also pay close attention to the individual progress of each student and devise tasks that are appropriate. Learner-centered teachers present students with "just manageable difficulties"—that is, challenging enough to maintain engagement, but not so difficult as to lead to discouragement. They must therefore have an understanding of their students' knowledge, skill levels, and interests (Duckworth, 1987).

2. **To provide a knowledge-centered classroom environment, attention must be given to what is taught (information, subject matter), why it is taught (understanding), and what competence or mastery looks like.** As mentioned above, research discussed in the report shows clearly that expertise involves well-organized knowledge that supports understanding, and that learning with understanding is important for the development of expertise because it makes new learning easier (i.e., supports transfer).

    Learning with understanding is often harder to accomplish than simply memorizing, and it takes more time. Many curricula fail to support learning with understanding because they present too many disconnected facts in too short a time—the "mile wide, inch deep" problem. Tests often reinforce memorizing rather than understanding. The knowledge-centered environment provides the necessary depth of study, assessing student understanding rather than factual memory. It incorporates the teaching of meta-cognitive strategies that further facilitate future learning.

Knowledge-centered environments also look beyond engagement as the primary index of successful teaching (Prawaf et al., 1992). Students' interest or engagement in a task is clearly important. Nevertheless, it does not guarantee that students will acquire the kinds of knowledge that will support new learning. There are important differences between tasks and projects that encourage hands-on doing and those that encourage doing with understanding; the knowledge-centered environment emphasizes the latter (Greeno, 1991).

3. **Formative assessments—ongoing assessments designed to make students' thinking visible to both teachers and students—are essential. They permit the teacher to grasp the students' preconceptions, understand where the students are in the "developmental corridor" from informal to formal thinking, and design instruction accordingly. In the assessment-centered classroom environment, formative assessments help both teachers and students monitor progress.**

   An important feature of assessments in these classrooms is that they be learner-friendly: they are not the Friday quiz for which information is memorized the night before, and for which the student is given a grade that ranks him or her with respect to classmates. Rather, these assessments should provide students with opportunities to revise and improve their thinking (Vye et al., 1998b), help students see their own progress over the course of weeks or months, and help teachers identify problems that need to be remedied (problems that may not be visible without the assessments). For example, a high school class studying the principles of democracy might be given a scenario in which a colony of people have just settled on the moon and must establish a government. Proposals from students of the defining features of such a government, as well as discussion of the problems they foresee in its establishment, can reveal to both teachers and students areas in which student thinking is more and less advanced. The exercise is less a test than an indicator of where inquiry and instruction should focus.

4. **Learning is influenced in fundamental ways by the context in which it takes place. A community-centered approach requires the development of norms for the classroom and school, as well as connections to the outside world, that support core learning values.**

   The norms established in the classroom have strong effects on students' achievement. In some schools, the norms could be expressed as "don't get caught not knowing something." Others encourage academic risk-taking and opportunities to make mistakes, obtain feedback, and

revise. Clearly, if students are to reveal their preconceptions about a subject matter, their questions, and their progress toward understanding, the norms of the school must support their doing so.

Teachers must attend to designing classroom activities and helping students organize their work in ways that promote the kind of intellectual camaraderie and the attitudes toward learning that build a sense of community. In such a community, students might help one another solve problems by building on each other's knowledge, asking questions to clarify explanations, and suggesting avenues that would move the group toward its goal (Brown and Campione, 1994). Both cooperation in problem solving (Evans, 1989; Newstead and Evans, 1995) and argumentation (Goldman, 1994; Habermas, 1990; Kuhn, 1991; Moshman, 1995a, 1995b; Salmon and Zeitz, 1995; Youniss and Damon, 1992) among students in such an intellectual community enhance cognitive development.

Teachers must be enabled and encouraged to establish a community of learners among themselves (Lave and Wegner, 1991). These communities can build a sense of comfort with questioning rather than knowing the answer and can develop a model of creating new ideas that build on the contributions of individual members. They can engender a sense of the excitement of learning that is then transferred to the classroom, conferring a sense of ownership of new ideas as they apply to theory and practice.

Not least, schools need to develop ways to link classroom learning to other aspects of students' lives. Engendering parent support for the core learning principles and parent involvement in the learning process is of utmost importance (Moll, 1990; 1986a, 1986b). Figure 1.2 shows the percentage of time, during a calendar year, that students in a large school district spent in school. If one-third of their time outside school (not counting sleeping) is spent watching television, then students apparently spend more hours per year watching television than attending school. A focus only on the hours that students currently spend in school overlooks the many opportunities for guided learning in other settings.

Applying the Design Framework to Adult Learning

The design framework summarized above assumes that the learners are children, but the principles apply to adult learning as well. This point is particularly important because incorporating the principles in this volume into educational practice will require a good deal of adult learning. Many approaches to teaching adults consistently violate principles for optimizing learning. Professional development programs for teachers, for example, frequently:

- *Are not learner centered.* Rather than ask teachers where they need help, they are simply expected to attend prearranged workshops.
- *Are not knowledge centered.* Teachers may simply be introduced to a new technique (like cooperative learning) without being given the opportunity to understand why, when, where, and how it might be valuable to them. Especially important is the need to integrate the structure of activities with the content of the curriculum that is taught.
- *Are not assessment centered.* In order for teachers to change their practices, they need opportunities to try things out in their classrooms and then receive feedback. Most professional development opportunities do not provide such feedback. Moreover, they tend to focus on change in teaching practice as the goal, but they neglect to develop in teachers the capacity to judge successful transfer of the technique to the classroom or its effects on student achievement.

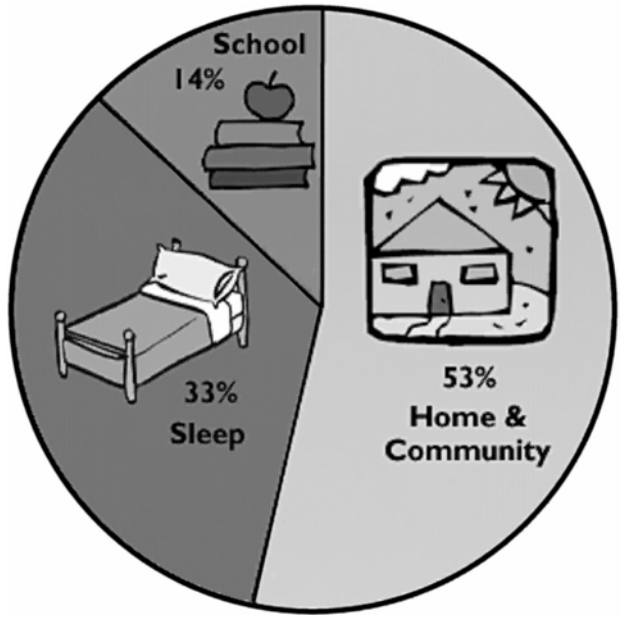


FIGURE 1.2 Students spend only 14 percent of their time in school.

- *Are not community centered.* Many professional development opportunities are conducted in isolation. Opportunities for continued contact and support as teachers incorporate new ideas into their teaching are limited, yet the rapid spread of Internet access provides a ready means of maintaining such contact if appropriately designed tools and services are available.

The principles of learning and their implications for designing learning environments apply equally to child and adult learning. They provide a lens through which current practice can be viewed with respect to K-12 teaching *and* with respect to preparation of teachers in the research and development agenda. The principles are relevant as well when we consider other groups, such as policy makers and the public, whose learning is also required for educational practice to change.

Improving STUDENT LEARNING

A Strategic Plan for Education Research and Its Utilization

Committee on a Feasibility Study for a Strategic Education Research Program
Commission on Behavioral and Social Sciences and Education
National Research Council
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COMMITTEE ON A FEASIBILITY STUDY FOR A STRATEGIC EDUCATION RESEARCH PROGRAM

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Executive Summary

Education in the United States currently consumes about 7 percent of the gross domestic product, yet the state of education is increasingly an issue of deep concern to parents, political leaders, employers, and the public generally. The recognition that many big-city schools, particularly the schools that serve poor children, have become failures for almost all students has given particular urgency to the issue of school reform. As *Education Week* (1998:6) put it recently, "It's hard to exaggerate the education crisis in America's cities."

One striking fact is that the complex world of education—unlike defense, health care, or industrial production—does not rest on a strong research base. In no other field are personal experience and ideology so frequently relied on to make policy choices, and in no other field is the research base so inadequate and little used. Comparatively little research is funded, and the task of importing even the strongest research findings into over a million classrooms is daunting.

In 1996 the National Research Council, the operating arm of the National Academy of Sciences and the National Academy of Engineering (henceforth, the Academies), launched a study to determine the feasibility of mounting a long-term, strategic program of research focused on a limited number of topics judged to be of crucial importance for improving student learning in the nation's schools.

Note: References are not included in this booklet but are available online at Search under title of report.

The study was conducted by a multidisciplinary committee composed of education researchers, practitioners, policy makers and other experts chosen to bring the widest possible range of perspectives to this task.

FOUR KEY QUESTIONS

The result of the committee's deliberations is a proposal for an ambitious and extraordinary experiment: the establishment of a Strategic Education Research Program (SERP) that would focus the energies of a significant number of researchers, practitioners, and policy makers on obtaining the answers to four specific, interrelated questions. The first three questions address fundamental issues in education:

- **How can advances in research on human cognition, development, and learning be incorporated into educational practice?**
- **How can student engagement in the learning process and motivation to achieve in school be increased?**
- **How can schools and school districts be transformed into organizations that have the capacity to continuously improve their practices?**

The committee selected these three questions for a number of reasons. Together they lie at the heart of education. It is possible, in seeking answers to them, to draw on substantial research as well as to imagine the outlines of future studies. They speak directly to the problems that teachers and school officials encounter and to the concerns of parents and the public more generally. Perhaps most important, they hold the potential for leveraging large improvements in student performance.

How to realize this potential is not self-evident. There is no doubt that educational practice can be strengthened by careful scientific research. But it is not clear how to make the integration of research findings an organic part of the education system. Therefore, the committee proposes a fourth and overarching research question:

- **How can the use of research knowledge be increased in schools and school districts?**

This question, expressed variously as knowledge utilization or knowledge mobilization, raises issues about the preparation of teachers so that they can be consumers of research, about the design of schools to create effective learning environments, and about bringing policy into alignment with new strategies for teaching and learning. Above all, however, it is about the *translation* of research findings into forms useful for educa

tional practice. It will require large-scale, systematic experimentation and demonstration to transform knowledge about human learning and the development of competence into the working vocabulary of teachers and schools.

THE PROPOSED STRATEGIC EDUCATION RESEARCH PROGRAM

To address these questions, the committee calls for a large-scale and sharply defined program of research, demonstration, and evaluation. Much of the work will need to be embedded in school settings; all of it should be informed by the needs of the most challenging schools, in particular, high-poverty urban schools. The likelihood of real accomplishment will be increased to the extent that a process of continuous incorporation of findings is used to create a flexible design for the array of SERP investigations.

To initiate and guide these activities, the committee proposes the establishment of four interconnected networks:

- a learning and instruction network,
- a student motivation network,
- a transforming schools network, and
- a utilization network.

Each network will include distinguished researchers working in partnership with practitioners and policy makers and supported by a national coalition of public and private funding organizations and other stakeholders, including legislators, state education agencies, teacher associations, organizations representing the research community, and other groups. Members of the four SERP networks would conduct research designed to help answer each network's hub question. They would also stimulate other researchers to undertake relevant studies, synthesize findings from their own and others' work, and plan future investigations. In addition, a major preoccupation of all four networks, but especially the fourth, would be to find ways to ensure utilization of the research by practitioners. A core premise of the plan is that the program of research, synthesis, and implementation activities will be strengthened by the interactions among researchers, practitioners, and policy makers in the networks.

Given the complexity of the issues, the magnitude of the research challenge, and the stakes involved, the committee strongly recommends that this program be implemented with the expectation that it will continue for at least 15 years. The committee is confident, however, that

significant contributions to educational systems will be possible within the first 5-7 years because a considerable body of potentially useful research already exists in each area.

The committee offers suggestions for organization and management of the overall program in the body of [the full] report. The suggestions do not add up to a blueprint for SERP; a detailed plan can only emerge through discussions among all the professional groups in education and the potential funders of the program —federal, state, and private. But we are proposing a new model for education research as the heart of the SERP idea. This new model has six of the crucial features: (1) promotion of collaborative and interdisciplinary work; (2) provision of constant, ongoing commitment on the part of core teams of researchers; (3) a built-in partnership with the practice and policy communities; (4) iterative and interactive interplay between basic and applied research in a structure that combines the richness of field-initiated research and the purpose of program-driven research; (5) a plan that is sustained over a long enough time for results to be cumulative; and (6) an overall structure that is cumulative in nature—each step planned to build on previous steps.

Our excitement about the idea of a Strategic Education Research Program has not blinded us to the risks. It is clear that the quality of both scientific and organizational leadership will determine its success. The intellectual and management challenges that will have to be met are formidable and will demand exceptional talent, commitment, and perseverance on the part of all of those responsible for it.

How This Plan Differs from Other Efforts

Many individuals and organizations have recognized the potential importance of research to education. There have been numerous university-based and district-based efforts to narrow the gap between research and practice. At the national level, the U.S. Department of Education and the National Educational Research Policy and Priorities Board have constructed a broad framework for education research, identifying seven broad challenges that warrant public investment. All these efforts continue to make important contributions to the nation's education, but they do not rigorously focus the nation's knowledge, resources, and energies in order to improve student learning. They do not promote the systematic use of research by teachers, administrators, and policy officials to improve student achievement. And because political priorities tend to change frequently, they tend not to produce sustained and cumulating knowledge.

The Strategic Education Research Program proposed in [the report] represents the first large-scale effort of its kind. By design, the SERP plan is focused, collaborative, cumulative, sustained, and solutions oriented.

- ***Focused*** SERP targets four hub research questions that hold great promise for strengthening learning in U.S. schools. This strategic focus will help harness the nation's powerful intellectual resources and expertise, making the networks more productive, more closely linked to classroom practice, and more accountable for demonstrable progress.
- ***Collaborative*** Finding answers to each of the hub research questions will require the combined insights of many fields—including cognitive functioning, social processes, and organizational change—as well as the deployment of the full array of research methods. Asking the right questions will require the wisdom of those who are deeply engaged in practice and the insights of policy makers. The organization of the effort through carefully coordinated networks of researchers, educators, and policy experts will promote the needed cross-fertilization that is commonly missing from current research efforts.
- ***Cumulative*** SERP recognizes that the traditional linear model of research —from basic research to applications—has not been productive in changing complex social systems like education. It envisions a new model of research, combining elements of field-initiated and program-driven research within a structure that will encourage a continuous process of taking stock so that each stage builds on what has been learned. Research or demonstrations in applied settings are as likely to define the next basic research questions as vice versa.
- ***Sustained*** SERP will function over a 15-year period (with decision points about continuation along the way), with constant, ongoing commitment on the part of its participants. Network members will maintain their own identities and activities in their particular professions and disciplines, but they will commit a substantial portion of their time and effort to network activities for more than a decade.
- ***Solutions Oriented*** SERP involves practitioners and policy makers in helping to define problems, devise solutions, and monitor the effects of research-based approaches. This built-in partnership with the policy and practice communities should have the healthy side-effect of cultivating a greater readiness on the part of local communities and schools to view research as a source of solutions for educational problems.

How This Plan Relates to Other Efforts

For the SERP idea to come to fruition, education leaders will need to see its potential for leveraging existing investments by federal and state governments, school systems, and private-sector organizations. The idea is not to replace important research and reform programs, but to strengthen them by finding unrealized synergies, providing a powerful

focus for the related activities, synthesizing what is known, and filling in gaps in the research. SERP could, for example, become a conduit for synthesizing and transmitting the findings from research, development, and demonstration projects supported by the Department of Education through its regional laboratories and research and development (R&D) centers; by the National Science Foundation through its cognitive research program, its new technology and learning centers, its Statewide Systemic Initiative (SSI); and by the National Institute for Child Health and Human Development, which has a strong program of research on the mechanisms of cognition and learning. SERP could also support the translation of research findings into practice by linking up with or supporting demonstration projects. Not least, it would support fledgling efforts to build better bridges, based on a foundation of mutual respect, between the practitioner and the research communities.

Why a Strategic Plan Is Needed

In part, the need for a strategic research plan grows out of the highly decentralized organization of education in the United States. More concretely, the answer lies with American students and American schools. Many students perform at high levels, but the nation's continued vitality as a democracy and its productivity in a global economy will hinge in coming decades on the knowledge and skills of the majority—the tens of millions of children who are not realizing their full capacities and are therefore unable to meet the intellectual demands of modern life and work.

Imagine what could be accomplished if the nation committed itself to a concerted effort to find out what needs to be known in order to improve achievement among these children. Imagine what they might achieve if the nation's leading researchers and education experts were to concentrate—not just for a month or a year, but for more than a decade—on how to facilitate and motivate their learning. That is the mission of the strategic plan for education research and its utilization presented in this report.

Next Steps

In the Preface [to the full report], Bruce Alberts [President, National Academy of Sciences] expresses his hope that this report will catalyze major new investments in education. As a first step, the National Academies propose to launch a year-long national dialogue during which the idea for a Strategic Education Research Program is discussed with all of the professional groups involved in education.

This committee strongly endorses that plan: We urge the federal

government—in particular, the Department of Education and the National Science Foundation—major foundations whose mission includes improving education, state and local education leaders, and education research organizations to join the Academies in this year of dialogue to see if, together, we can transform the SERP idea into a productive collaboration to use the power of science to improve education in the United States.

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