THE PROCESS OF EDUCATION

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FOR

JANE, ANGUS, BONNIE, WHIT, LYN, SANDY,
AND JOCK

PREFACE, 1977

One does not usually like to brood long over books published. One either gets on to something else or, having brooded well, publishes a revised edition. But I confess that, in spite of getting on to something else, I have been unable either to put this volume behind me or to revise it—though I have written two books that are postscripts to it, *Toward a Theory of Instruction* and *The Relevance of Education.*

There are several reasons for this prolonged brooding. For one, the book has been caught up in educational debate, first in America and then, with translation, in other countries where the major issues at stake were quite different from those in America, countries ranging in ideology from Russia to Japan, from Denmark to Mexico. And, obviously, the seventeen years since its first publication have been years of intense and profound debate about education. For another, I confess that the book's initial reception and the widespread comment it produced surprised me. It was a surprise that a book expressing so structuralist a view of knowledge and so intuitionist an approach to the process of knowing should attract so much attention in America, where empiricism had long been the dominant voice and "learning theory" its amplifier. The volume has plainly been part of a change that included the emergence of other structuralist accounts of human knowing as well—notably Piaget, Chomsky, and Lévi-Strauss. I have little doubt, looking back now, that all three had a profound effect on my thinking. In the ensuing years, I was very much caught up intellectually in the work of the first two of these men and was a distant admirer of the third. As their work took new form, so did my thoughts about the process of education—mostly after the publication of this book. And finally, in the years after the book I found myself (again rather by surprise) increasingly involved in that part of the educational enterprise called "curriculum development," and then directed a team that put together *Man: A Course of Study*, a school curriculum in the human sciences. It too kept turning my thoughts back to this volume.

It seems appropriate then, in writing this preface to the new Harvard Paperback of *The Process of Education*, to say a word about each of these matters, for I think that the three are closely related.

First, about the role of this book in the debates on education in America and elsewhere. The idea that knowledge in any field of study has a derivational structure, that a science, for example, is a very canny way of dealing with a very large range of particularities while keeping very little in mind in doing so, is hardly a new idea. Indeed, it is the heart of Platonism, and advances in physics, chemistry, and biology have been based upon developing a set of underlying theorems and paradigms from which particulars can be derived. Chomsky in his recent *Reflections on Language* speculates that there may be certain natural, even "innate" ways of organizing knowledge, which are possibly more powerful in treating the realm of "things" than in dealing with the domain of people and their acts and intentions. It may well be that we may not so readily be able to find an axiomatic deep structure in politics, economics, and the humanities, that the forms of connection between events and ideas in these domains are not only different from those in the sciences but intrinsically less accessible to human minds. Be that as it may, the advances of knowledge in the last half century have been such as to lead any thoughtful man, especially one interested in education, to seek fresh ways of transmitting to a new generation the fund of learning that had been growing at such a rapid rate. It seemed natural that emphasis should shift to teaching basic principles, underlying axioms, pervasive themes, that one should "talk physics" with students rather than "talk about" it to them. We may indeed now know a great deal more about the difficulties involved in such an approach, but it is still the only one that makes much sense, if the object is to transmit knowledge and to create intellectual skill.

The program envisaged for such an objective was in the form of a "spiral curriculum." One approached knowledge in the spirit of making it accessible to the problem-solving learner by modes of thinking that he already possessed or that he could, so to speak, assemble by combining natural ways of thinking that he had not previously combined. One starts somewhere—where the learner *is*. And one starts *whenever* the student arrives to begin his career as a learner. It was in this spirit that I proposed that "any subject could be taught to any child at any age in some form that is honest." One matched the problem to the learner's capacities or found some aspect of the problem that could be so matched. That was the spirit behind the dictum. It has sometimes been gravely misinterpreted, as when I am asked, "Do you *really* think the calculus can be taught to six-year-olds?" That is surely not the point. One can certainly get across the idea of limits to the six-year-old, and that is an honest step en route to grasping a basic idea in the calculus.

The debates to which I alluded, in America and elsewhere, took various forms. All of them were polarized around some version of a contrastive pair: the book's view was too cognitive in contrast to some other view that was more affective, more pragmatic, more political, more "traditional." In America, where more than elsewhere the school is seen as an instrument for teaching social and emotional skills, critics pointed to Bloom's *Taxonomy of Educational Objectives* as source for the charge that the program being proposed was one-sidedly devoted to the training of mind. Critics like Richard Jones in *Fantasy and Feeling in Education* proposed an orientation in education that was more given to self-discovery. And, surely, one cannot fault such criticisms—save to note that there need be no conflict between fostering intellectual power and cultivating emotional maturity. In the Soviet Union, where the first translation of the book appeared, its "message" (if such it can be called) was taken as a weapon in the battle against politically inspired dogmatism in the schools, as a program likely to produce more independence of mind. In Japan the book achieved wide currency as a voice against the rote traditionalism of classical education. In Italy, the battle was three-sided and intense: Marxists attacked the book as a form of epistemological idealism (and therefore bourgeois) and classicists saw it as an attack on humanistic learning in the great scholastic tradition. In all of these confrontations, it was quite plain that debate about education was not just about education but about political ideals and ideology. It was perhaps Michael Cole, more than any other, who made me realize the deep connection between politics and education by pointing out that the introduction of a Western European ideal into African schooling, implicitly pressing the child to become his own thinker and his own authority, in effect undermined the traditional authority structure of the indigenous society. One cannot change education without affecting much else in the society as well—if the change takes, and it often fails to do so by virtue of running headlong into a contradictory set of cultural ideals. And so when the battle is joined over the "comprehensivization" of the British school system, the debate, in fact, is only indirectly about education and far more directly about the British class system.

In America, particularly, the issue of curriculum as a means of cultivating intellect was very soon swamped by another matter. By the mid-1960s deep social forces were producing an unforeseen turmoil in the American school. They seemed to come out of a common source: a striving for a new equality, for a fresh redefinition of the nature of society. Initially, the push came from the aspiring American black community seeking a legitimate share in American life, including the opportunity for education at its best. The widespread discontent created by this "revolution of rising expectations" was then many times amplified by the turmoil of the Vietnam war in which many Americans discovered unsuspected corruption and callousness—and this was felt nowhere more deeply than among the young. The young felt as never before that they had to go it on their own. There were surely other factors as well that led to what, by the late sixties, was widespread alienation from the society and from its schools—schools being that part of the society with which the young were most closely in touch. In such an atmosphere of moral crisis, the issue of curriculum paled in significance as the cry for more "relevance" in education rose in volume. I recall a visit in those dark and stirring days from my friend Ivan Illich, who by then was convinced that the school was the principal enslaver, the prime instrument of an unjust society for creating a "malleable and just sufficiently skilled labor force." As Fred Hechinger of *The New York Times* recently put it, the educational system had become a target of attack rather than a means to be improved.

But again, we are witnessing another redressing of the balance. James Callaghan's speech at Ruskin College, Oxford, was the first Prime Ministerial pronouncement on matters of education since Gladstone; President Carter chose as his running mate a senator whose reputation as an educational statesman in the Congress was preeminent. Neville Bennett's *Teaching Styles and Pupil Progress* has reopened the discussion of how to conceive of the teacher's role, and Great Britain, by proclamation, if not in fact, is about to launch a national debate on a national curriculum. But one had best be cautious in predicting where educational debate will lead. In the pages of this book there is no mention of the dropout, very little if any awareness of the problem of alienation from school and society, and not a suspicion of deschooling.

Let me now turn to the less worldly matter of the changing intellectual scene of which this book is a part. I recall, while I was writing it, George Miller's bringing to my attention Chomsky's new *Syntactic Structures*, and remember reading with excitement his powerful rejection of finite-state grammars that tried to explain the order in language by invoking a form of chain-linking of neighboring words in a sentence. He insisted and proved that the formation and transformation rules of a sentence had to be grasped as a whole by a speaker if he was ever to be able to utter sentences with any degree of embedding (or to comprehend ones like the one you are just concluding). Had I fully grasped then the significance of what Chomsky was saying, I would surely have been tempted to analyze educational achievement in terms of competence and performance, with the latter being a set of surface expressions of the former. And as with language whose rules are based on intuitively simple concepts such as ordering, substituting, transposing, and the like, so too the deep understanding of any subject depends upon such intuitively simple concepts as cause and effect, transitivity, and equivalence. Yet there is something more to it than that. Chomsky's formalism, like Piaget's, has become less and less attractive. They have both been carried away from the functional concern that initiated their enterprises—the adaptive "reasons" that impel or motivate the intellectual activity. In recent years, functionalism has returned to linguistics with the emergence of "speech act" theory—John Austin's *How to Do Things with Words* appeared a year after *Process* and its full impact on linguistic pragmatics is only now beginning to be fully appreciated. And the new departures of Bärbel Inhelder in Geneva, studying the conditions under which hypotheses become susceptible to change, are redressing Piagetian formalism. My own work, first in cognitive development, then in early language acquisition, has also pushed me in the direction of studying the role of function in creating mental and language structural rules.

Indeed, I find the discussion of pedagogy in the pages of this book to be almost unrealistically airy. I come to the opinion partly through matters related below, but just as much from my own research on the nature of "adult tuition" in both early problem solving and in language acquisition. With respect to the former, there is a vast amount of skilled activity required of a "teacher" to get a learner to discover on his own—scaffolding the task in a way that assures that only those parts of the task within the child's reach are left unresolved, and knowing what elements of a solution the child will recognize though he cannot yet perform them. So too with language acquisition: as in all forms of assisted learning, it depends massively upon participation in a dialogue carefully stabilized by the adult partner. So much of learning depends upon the need to achieve joint attention, to conduct enterprises jointly, to honor the social relationship that exists between learner and tutor, to generate possible worlds in which given propositions may be true or appropriate or even felicitous: to overlook this functional setting of learning—whatever its content—is to dry it to a mummy.*

So, while in 1960 a structuralist view of knowledge seemed out of the main current of American thought, particularly when related to educational matters, it no longer seems so. Indeed, functional and motivational considerations seem now to be taking a more central position in the revision of what have now almost become "establishment" views.

Let me turn finally to the last of the things that have kept me brooding about this book—the production of a curriculum. Whoever has undertaken such an enterprise will probably have learned many things. But with luck, he will also have learned one big thing. A curriculum is more for teachers than it is for pupils. If it cannot change, move, perturb, inform teachers, it will have no effect on those whom they teach. It must be first and foremost a curriculum for teachers. If it has any effect on pupils, it will have it by virtue of having had an effect on teachers. The doctrine that a well-wrought curriculum is a way of "teacher-proofing" a body of knowledge in order to get it to the student uncontaminated is nonsense. *The Process of Education*, in that sense, is only part of a book, for it is mostly about students and their learning processes. Perhaps it is not a surprise that the book most immediately following it bore the title *Toward a Theory of Instruction*.

*The interested reader is referred to J. S. Bruner, *Entry into Early Language: A Spiral Curriculum*, Charles Gittings Memorial Lecture, University College, Swansea (Swansea, Crown Printers, 1975); David Wood, J. S. Bruner, and Gail Ross, "The Role of Tutoring in Problem Solving," *Journal of Child Psychology and Psychiatry* 17 (1976), 89–100; and J. S. Bruner, "The Nature and Uses of Immaturity," *American Psychologist* 27 (1972), 1–22.

Having said this much, I am bound to answer the query why I did not, in good time, write a second edition of this book, having brooded as much as I confess to having done. I do not think it was possible to do so. The book was a creature of its time, place, and circumstances, for better or worse. The changes that it produced in my mind, just by virtue of its having been written and put into the public domain, are recorded in my later work (a sample of which can be found in Jeremy Anglin's collection *Beyond the Information Given*, which includes his shrewd commentary on the course of that work since 1960).

I want, finally, to express my gratitude to the Harvard University Press for having kept this little book flourishing all these years, and for giving me this chance to say a few words about what has happened in the meanwhile.

Jerome S. Bruner

Oxford
January 1977

PREFACE

In September 1959 there gathered at Woods Hole on Cape Cod some thirty-five scientists, scholars, and educators to discuss how education in science might be improved in our primary and secondary schools. The ten-day meeting had been called by the National Academy of Sciences, which, through its Education Committee, had been examining for several years the long-range problem of improving the dissemination of scientific knowledge in America. The intention was not to institute a crash program, but rather to examine the fundamental processes involved in imparting to young students a sense of the substance and method of science. Nor was the objective to recruit able young Americans to scientific careers, desirable though such an outcome might be. Rather, what had prompted the meeting was a conviction that we were at the beginning of a period of new progress in, and concern for, creating curricula and ways of teaching science, and that a general appraisal of this progress and concern was in order, so as to better guide developments in the future.

Major efforts in curriculum design had been launched by leading physicists, mathematicians, biologists, and chemists, and similar projects were in prospect in other fields of scientific endeavor. Something new was stirring in the land. A tour of the United States in the summer of 1959 would have revealed a concentration of distinguished mathematicians in Boulder, Colorado, engaged in writing new textbooks for primary, junior high, and high school grades. In Kansas City, there could be found a group of first-class biologists busily producing films on subjects such as the structure of the cell and photosynthesis for use in tenth-grade biology courses. In Urbana, Illinois, there was a flurry of work on the teaching of fundamental mathematical concepts to grade-school children, and in Palo Alto one might have found a mathematical logician at work trying out materials for teaching geometry to children in the beginning grades of school. In Cambridge, Massachusetts, work was progressing on an "ideal" physics course for high school students, engaging the efforts not only of text writers and film producers but also of men who had earned world renown in theoretical and experimental physics. At various centers throughout the country, teachers were being trained to teach this new physics course by others who had already tried it. Preliminary work was under way in Boulder on a junior high school course in biology, and a group of chemists were similarly engaged in their field in Portland, Oregon. Various learned societies were searching for and finding ways of establishing contact between their leading scholars and educators in the schools. For their part, educators and psychologists were examining anew the nature of teaching methods and curricula and were becoming increasingly ready to examine fresh approaches. The time was indeed ripe for an over-all appraisal of the situation.

Various organizations charged with one or another responsibility in the field of scientific education and research had also reached a point at which a general examination of progress and prospects was in order. The National Academy of Sciences had engaged in considerable discussion about the manner in which it might facilitate a closer relation between scientists in universities and those charged with teaching in schools, as had the American Association for the Advancement of Science and the Carnegie Corporation of New York. These organizations were generous in their counsel during the planning of the Conference. The National Science Foundation had, so to speak, already gone into business: it was principally through its financial aid and moral support that various of the curriculum projects mentioned above had got under way. It also provided financial support for the Woods Hole Conference, as did the United States Office of Education, the Air Force, and the RAND Corporation.

The Conference, whose members are listed at the head of the book, was unique in composition. Virtually all of the curriculum projects mentioned earlier were represented by scientists who had been engaged in the process of writing texts, teaching the new courses, or preparing films or other materials. In addition, there were psychologists who had devoted a major part of their research lives to the examination of intelligence, learning, remembering, thinking, and motivation. Strange as it may seem, this was the first time psychologists had been brought together with leading scientists to discuss the problems involved in teaching their various disciplines. The psychologists themselves represented a wide spectrum of points of view—behavioristic, Gestalt, psychometric, the developmental viewpoint of the Geneva school, and the rest.

The differences, however, paled before the issues that were to be faced. The group was leavened by a representation of professional educators—teachers, deans, experts in audio-visual methods. Two of the Conference members, finally, were historians. It had been our conviction in planning the Conference that it would be unwise to limit ourselves exclusively to the teaching of science, that the eventual problem would be more general than that, and that it would be in the interest of perspective to compare the issues involved in teaching science with those in a more humanistic field, such as history. The conviction turned out to be a sound one, and our historians contributed mightily to the proceedings.

The conduct of the Conference at Woods Hole will help explain the existence of this book. The opening days were given over to a round-the-clock series of progress reports and appraisals of the work of various curriculum projects—the School Mathematics Study Group, the University of Illinois Committee on School Mathematics, the University of Illinois Arithmetic Project, the Minnesota School Mathematics Center, the Biological Sciences Curriculum Study, and the Physical Science Study Committee. In addition, there were searching reports on requirements for a curriculum in American history. We also took time to examine some recent research related to the educational effort. Demonstration films were shown by Dr. Richard Suchman on the Illinois Studies in Inquiry Training, dealing with how children may be educated to the formulation of searching questions, and also by Dr. Bärbel Inhelder on the recent work of the Geneva group on the thought processes of young children. Indeed, lest the Conference get too remote from the direct problems of teaching, an afternoon was given over to a class demonstration of the techniques used by the Illinois Arithmetic Project, with Dr. David Page, its director, serving as teacher. Teaching machines were demonstrated by Professor B. F. Skinner of Harvard, and the demonstration led to a lively, at times stormy, discussion. Late in those opening evenings, one could relax to instructional films in biology and physics. Time was well filled.

A few days after the Conference opened, its members were divided into five work groups—one concerned with the "Sequence of a Curriculum," a second with "The Apparatus of Teaching," a third with "The Motivation of Learning," a fourth with "The Role of Intuition in Learning and Thinking," and a fifth with "Cognitive Processes in Learning." * The second half of the Conference was devoted almost wholly to the activities of these work groups. Each prepared a lengthy report, and as these were being readied, they were presented to the Conference for debate. While there was considerable

* The members of the various work groups were as follows: "Sequence of a Curriculum," John Blum, Gilbert Finlay, Arnold Grobman, Robert S. Morison, William C. H. Prentice, Herbert E. Vaughan; "The Apparatus of Teaching," C. Ray Carpenter, John B. Carroll, John H. Fischer, John Flory, H. Bentley Glass, Donald Taylor, Don Williams; "The Motivation of Learning," Richard Alpert, Lee J. Cronbach, John F. Latimer, Richard Pieters, Paul C. Rosenbloom, Kenneth W. Spence; "The Role of Intuition in Learning and Thinking," Henry Chauncey, Robert M. Gagne, Ralph Gerard, George A. Miller, Jerrold Zacharias; "Cognitive Processes in Learning," Edward G. Begle, Jerome S. Bruner, Donald Cole, Francis L. Friedman, Bärbel Inhelder, David L. Page, H. Burr Steinbach. An Executive Committee served to coordinate the work of the Conference. It consisted of Edward G. Begle, John Blum, Henry Chauncey, Lee J. Cronbach, Francis L. Friedman, Arnold Grobman, Randall M. Whaley, and Jerome S. Bruner, *Chairman*.

agreement in the various work groups on major emphases, plenary sessions of the Conference were more concerned with debating the issues, and no effort was made to reach a consensus of the Conference as a whole. And herein lies the origin of the present book.

The reports of the various work groups, copies of which can be obtained through the National Academy of Sciences in Washington, were obviously prepared under pressure and with a view to debate. They were not designed to be definitive statements or manifestoes. Yet there were certain recurrent themes that emerged in these reports and at the Conference generally, and it would have been unfortunate indeed to lose these in the maze of compromise wherein thirty-five spirited men reach agreement on what should constitute a final report.

It fell to the Chairman, then, to prepare a Chairman's Report—perforce a selective account of what in his view were the major themes, the principal conjectures, and the most striking tentative conclusions reached. In a proper sense it is the Chairman who is principally responsible for the pages that follow, however much he made every effort to reflect the thought of his colleagues. In drafting the present document, consequently, I have made liberal use of the papers prepared by the work groups and of notes taken at the plenary sessions. In preparing a first draft of the Report for circulation, I leaned particularly upon two members of the Conference, Professor Francis Friedman of M.I.T. and Dr. Richard Alpert of Harvard, who helped not only in the preparation of outlines but also in drafting some of the ideas contained in the outlines. When a first draft of the Chairman's Report was completed, copies of it were sent to all of the members of the Conference for comment and criticism. Several colleagues wrote long commentaries; virtually all had their say in the margins. There were amplifications, dissents here and there, expressions of affirmation, urgings to more extreme statements or cautions against them, a few complaints about ideas omitted and some about ones that had been included or added in the spirit of retrospect. One extended comment pressed the point that the views of Piaget concerning the transition from preoperational to operational thought had been given too prominent a place in the Report. Another complained that the first draft had given short shrift to the problem of teaching aids and had neglected the views of our audio-visual professionals who had urged a "balanced system of teaching aids" consisting of well-tested devices. In the end, the section on aids was expanded, although the doctrine of the "balanced system" was subordinated to what appeared to me to be the prevailing view of the discussions: that aids are instruments to help attain an educational objective, and that it is these objectives and not the existence of apparatus that determine balance.

In short, the preparation of a final draft was greatly aided by the comments of participants—though again it was not undertaken in the spirit of trying to find a consensus. Rather, the pages that follow constitute my conception of the "sense of the meeting" and inevitably will reflect the biases and predilections I bring to the task. At the same time, this book represents a set of views that grew out of the Conference and intense correspondence that followed it.

In preparing the final draft, in the winter following the Conference, I benefited particularly from several helpful discussions with Woods Hole colleagues. Perhaps the most thorough going-over of the final draft took place in Urbana, Illinois, where Lee Cronbach, Gilbert Finlay, and David Page joined me in what amounted to an intensive seminar on points that had remained moot after the months of correspondence and exchanging of drafts. In Cambridge, I also had the benefit of continuing discussion with my colleagues Richard Alpert and George Miller of Harvard, and Francis Friedman and Jerrold Zacharias of M.I.T. Two men closely associated with primary and secondary education who were not at Woods Hole, Mr. Paul Brandwein and Mr. Edward Yeomans, have also read and commented on the manuscript.

In a cooperative enterprise such as this, there are many people who come to deserve special gratitude. Foremost among these is the man who not only had the idea of calling the Conference, but who implemented it in all possible ways by his intelligent and devoted labors. Dr. Randall Whaley, Director of the Education Office in the National Academy of Sciences, had the idea, arranged for the financing of the Conference and for its housing, helped recruit its members, and generally served to keep the proceedings moving effectively. Dr. Whaley was on leave to the National Academy from Purdue University, where he has now returned as Associate Dean of Sciences. The work of the Conference itself was enormously facilitated by the hard and subtle labors of a staff consisting of Mrs. Eleanor Horan of Harvard University, Mrs. Elizabeth Ramsey of the National Academy of Sciences, Miss Mildred Runciman of the Rockefeller Foundation, and Miss Margaret Gazan of M.I.T. Mr. Robert Green of the National Academy expedited countless details ranging from having cars meet men who arrived on airplanes in the weather-bedeviled schedules of Cape Cod to obtaining the cooperation of children for demonstrations of the teaching of arithmetic. Finally, it would be difficult to express sufficient thanks to the many kind offices done us by Rear Admiral B. van Mater, U.S.N. (ret.), and his staff at Woods Hole. We were housed in the summer headquarters of the National Academy there, with Admiral van Mater as a most effective chief administrative officer.

I should like also to express my thanks to Harvard University for handling many financial details of the Conference on behalf of the National Academy and particularly to the Director of the Harvard Office for Research Contracts, Mr. Richard Pratt, who combines administrative acumen and a sense of humor to an extraordinary degree.

Many of the ideas that emerged at the Conference and after have long and honorable lineages in the history of educational thought. I, as Chairman of the Conference and author of this Report, apologize for the virtual absence of bibliographical citation in the pages that follow. Our thinking has been shaped and aided, obviously, by the literature related to this subject—and it is a vast literature. In writing this book, I have not sought to do justice to the parentage of ideas, a task more properly undertaken by a more scholarly volume. One such volume, containing a wisely assembled collection of readings, is Professor Robert Ulich's *Three Thousand Years of Educational Wisdom* (Cambridge, Massachusetts, 1959).

Thanks are due, finally, to Harvard University Press for thoughtful and swift publishing.

Jerome S. Bruner

Cambridge, Massachusetts
May 1960

MEMBERS OF THE WOODS HOLE CONFERENCE

Dr. Carl Allendoerfer	University of Washington	Mathematics
Dr. Richard Alpert	Harvard University	Psychology
Dr. Edward Begle	Yale University	Mathematics
Dr. John Blum	Yale University	History
Dr. Jerome S. Bruner, Director	Harvard University	Psychology
Dr. C. Ray Carpenter	Pennsylvania State University	Psychology
Dr. John B. Carroll	Harvard University	Education
Dr. Henry Chauncey	Educational Testing Service	Education
Mr. Donald Cole	Phillips Exeter Academy	History
Dr. Lee Cronbach	University of Illinois	Psychology
Mr. Gilbert Finlay	University of Illinois	Physics
Dr. John H. Fischer	Teacher's College, Columbia University	Education
Mr. John Flory	Eastman Kodak Company	Cinematography
Dr. Francis L. Friedman	Massachusetts Institute of Technology	Physics
Dr. Robert M. Gagne	Princeton University	Psychology
Dr. Ralph Gerard	University of Michigan	Biology
Dr. H. Bentley Glass	Johns Hopkins University	Biology
Dr. Arnold Grobman	American Institute of Biological Sciences	Biology
Dr. Thomas S. Hall	Washington University	Biology
Dr. Bärbel Inhelder	Institut Rousseau, Geneva	Psychology
Dr. John F. Latimer	George Washington University	Classics
Dr. George A. Miller	Harvard University	Psychology
Dr. Robert S. Morison	Rockefeller Foundation	Medicine
Dr. David L. Page	University of Illinois	Mathematics
Mr. Richard Pieters	Phillips Academy, Andover	Mathematics
Dr. Wm. C. H. Prentice	Swarthmore College	Psychology
Dr. Paul C. Rosenbloom	University of Minnesota	Mathematics
Dr. Kenneth W. Spence	State University of Iowa	Psychology
Dr. H. Burr Steinbach	University of Chicago	Biology
Dr. Donald Taylor	Yale University	Psychology
Dr. Herbert E. Vaughan	University of Illinois	Mathematics
Dr. Randall M. Whaley	Purdue University	Physics
Dr. Don Williams	University of Kansas City	Cinematography
Dr. Jerrold Zacharias	Massachusetts Institute of Technology	Physics

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INTRODUCTION

EACH generation gives new form to the aspirations that shape education in its time. What may be emerging as a mark of our own generation is a widespread renewal of concern for the quality and intellectual aims of education—but without abandonment of the ideal that education should serve as a means of training well-balanced citizens for a democracy. Rather, we have reached a level of public education in America where a considerable portion of our population has become interested in a question that until recently was the concern of specialists: "What shall we teach and to what end?" The new spirit perhaps reflects the profound scientific revolution of our times as well. The trend is accentuated by what is almost certain to be a long-range crisis in national security, a crisis whose resolution will depend upon a well-educated citizenry.

One of the places in which this renewal of concern has expressed itself is in curriculum planning for the elementary and secondary schools. Several striking developments have taken place. There has been an unprecedented participation in curriculum development by university scholars and scientists, men distinguished for their work at the frontiers of their respective disciplines. They have been preparing courses of study for elementary and secondary schools not only reflecting recent advances in science and scholarship but also embodying bold ideas about the nature of school experience. Perhaps the most highly developed curriculum of this kind is the physics course for high schools prepared by the Physical Science Study Committee, a course for which textbooks, laboratory exercises, films, and special teaching manuals have been prepared, as well as training courses for teachers. Some twenty-five thousand high school students are taking this course, and its impact is now being studied. There are similar projects in the field of mathematics under the supervision of the School Mathematics Study Group, the Commission on Mathematics, the University of Illinois Committee on School Mathematics, and other groups. The Biological Sciences Curriculum Study is constructing a high school biology course, and work of a comparable nature is under way in chemistry and other fields.

The main objective of this work has been to present subject matter effectively—that is, with due regard not only for coverage but also for structure. The daring and imagination that have gone into this work and the remarkable early successes it has achieved have stimulated psychologists who are concerned with the nature of learning and the transmission of knowledge. The Woods Hole Conference, the background and conduct of which are described in the Preface, was one response to this stimulation of interest. Physicists, biologists, mathematicians, historians, educators, and psychologists came together to consider anew the nature of the learning process, its relevance to education, and points at which current curricular efforts have raised new questions about our conceptions of learning and teaching. What shall be taught, when, and how? What kinds of research and inquiry might further the growing effort in the design of curricula? What are the implications of emphasizing the structure of a subject, be it mathematics or history—emphasizing it in a way that seeks to give a student as quickly as possible a sense of the fundamental ideas of a discipline?

An additional word of background is needed to appreciate the significance of present curricular efforts in the changing educational scene. The past half century has witnessed the rise of the American university graduate school with its strong emphasis upon advanced study and research. One consequence of this development has been the growing separation of first-rank scholars and scientists from the task of presenting their own subjects in primary and secondary schools—indeed even in elementary courses for undergraduates. The chief contact between those on the frontiers of scholarship and students in schools was through the occasional textbooks for high schools prepared by such distinguished scientists as Millikan or by historians of the stature of Beard or Commager. For the most part, however, the scholars at the forefront of their disciplines, those who might be able to make the greatest contribution to the substantive reorganization of their fields, were not involved in the development of curricula for the elementary and secondary schools. In consequence, school programs have often dealt inadequately or incorrectly with contemporary knowledge, and we have not reaped the benefits that might have come from a joining of the efforts of eminent scholars, wise and skillful teachers, and those trained in the fields related to teaching and learning. Now there appears to be a reversal of this trend. It consists in the renewed involvement of many of America's most distinguished scientists in the planning of school study programs in their field, in the preparation of textbooks and laboratory demonstrations, in the construction of films and television programs.

This same half century saw American psychology move away from its earlier concern with the nature of learning as it occurs in school. The psychology of learning tended to become involved with the precise details of learning in highly simplified short-term situations and thereby lost much of its contact with the long-term educational effects of learning. For their part, educational psychologists turned their attention with great effect to the study of aptitude and achievement and to social and motivational aspects of education, but did not concern themselves directly with the intellectual structure of class activities.

Other considerations led to a neglect of curriculum problems by psychologists. The ever-changing pattern of American educational philosophy played a part in the matter as well. There has always been a dualism in our educational ideal, a striving for a balance between what Benjamin Franklin referred to as the "useful" and the "ornamental." As he put it, in the mid-eighteenth century: "It would be well if they could be taught everything that is useful and everything that is ornamental: but art is long and their time is short. It is therefore proposed that they learn those things that are likely to be most useful and most ornamental." The concept of the useful in Franklin and in the American educational ideal afterwards was twofold: it involved, on the one hand, *skills* of a specific kind and, on the other, *general understanding*, to enable one better to deal with the affairs of life. Skills were matters of direct concern to one's profession. As early as the 1750's we find Ben Franklin urging that future merchants be taught French, German, and Spanish, and that pupils be taught agriculture, supplemented by farm visits and the like. General understanding was to be achieved through a knowledge of history plus the discipline produced by the diligent study of mathematics and logic, and by training in careful observation of the natural world around one; it required a well-disciplined, well-stocked mind.

The American secondary school has tried to strike a balance between the two concepts of usefulness—and most often with some regard for the ornamental as well. But as the proportion of the population registered in secondary schools increased, and as the proportion of new Americans in the school population went up, the balance between instruction in the useful skills and in disciplined understanding was harder to maintain. Dr. Conant's recent plea for the comprehensive high school is addressed to the problem of that balance.

It is interesting that around the turn of the last century the conception of the learning process as depicted by psychology gradually shifted away from an emphasis upon the production of general understanding to an emphasis on the acquisition of specific skills. The study of "transfer" provides the type case—the problem of the gain in mastery of other activities that one achieves from having mastered a particular learning task. Whereas the earlier emphasis had led to research studies on the transfer of formal discipline—the value obtained from the training of such "faculties" as analysis, judgment, memory, and so forth—later work tended to explore the transfer of identical elements or specific skills. In consequence, there was relatively little work by American psychologists during the first four decades of this century on the manner in which the student could be trained to grasp the underlying structure or significance of complex knowledge. Virtually all of the evidence of the last two decades on the nature of learning and transfer has indicated that, while the original theory of formal discipline was poorly stated in terms of the training of faculties, it is indeed a fact that massive general transfer can be achieved by appropriate learning, even to the degree that learning properly under optimum conditions leads one to "learn how to learn." These studies have stimulated a renewed interest in complex learning of a kind that one finds in schools, learning designed to produce general understanding of the structure of a subject matter. Interest in curricular problems at large has, in consequence, been rekindled among psychologists concerned with the learning process.

A word is needed at this point to explain in fuller detail what is meant by the *structure* of a subject, for we shall have occasion to return to this idea often in later pages. Three simple examples—from biology, from mathematics, and from the learning of language—help to make the idea clearer. Take first a set of observations on an inchworm crossing a sheet of graph paper mounted on a board. The board is horizontal; the animal moves in a straight line. We tilt the board so that the inclined plane or upward grade is 30°. The animal does not go straight up the line of maximum climb, but travels at an angle of 45° from it. We tilt the board to 60°. At what angle does the animal travel with respect to the line of maximum climb? His path now makes a 67½° angle with it, that is, he travels along a line 75° off the vertical. We may thus infer that inchworms "prefer" to travel uphill, if uphill they must go, along an incline of 15°. We have discovered a tropism, as it is called, indeed a geotropism. It is not an isolated fact. We can go on to show that among simple organisms, such phenomena—regulation of locomotion according to a fixed or built-in standard—are the rule. There is a preferred level of illumination toward which lower organisms orient, a preferred level of salinity, of temperature, and so on. Once a student grasps this basic relation between external stimulation and locomotor action, he is well on his way toward being able to handle a good deal of seemingly new but, in fact, highly related information. The swarming of locusts where temperature determines the swarm density in which locusts are forced to travel, the species maintenance of insects at different altitudes on the side of a mountain where crossbreeding is prevented by the tendency of each species to travel in its preferred oxygen zone, and many other phenomena in biology can be understood in the light of tropisms. Grasping the structure of a subject is understanding it in a way that permits many other things to be related to it meaningfully. To learn structure, in short, is to learn how things are related.

Much more briefly, to take an example from mathematics, algebra is a way of arranging knowns and unknowns in equations so that the unknowns are made knowable. The three fundamentals involved in working with these equations are commutation, distribution, and association. Once a student grasps the ideas embodied by these three fundamentals, he is in a position to recognize wherein "new" equations to be solved are not new at all, but variants on a familiar theme. Whether the student knows the formal names of these operations is less important for transfer than whether he is able to use them.

The often unconscious nature of learning structures is perhaps best illustrated in learning one's native language. Having grasped the subtle structure of a sentence, the child very rapidly learns to generate many other sentences based on this model though different in content from the original sentence learned. And having mastered the rules for transforming sentences without altering their meaning—"The dog bit the man" and "The man was bitten by the dog"—the child is able to vary his sentences much more widely. Yet, while young children are able to *use* the structural rules of English, they are certainly not able to say what the rules are.

The scientists constructing curricula in physics and mathematics have been highly mindful of the problem of teaching the structure of their subjects, and it may be that their early successes have been due to this emphasis. Their emphasis upon structure has stimulated students of the learning process. The reader will find the emphasis reflected many times in the pages that follow.

Clearly there are general questions to be faced before one can look at specific problems of courses, sequences, and the like. The moment one begins to ask questions about the value of specific courses, one is asking about the objectives of education. The construction of curricula proceeds in a world where changing social, cultural, and political conditions continually alter the surroundings and the goals of schools and their students. We are concerned with curricula designed for Americans, for their ways and their needs in a complex world. Americans are a changing people; their geographical mobility makes imperative some degree of uniformity among high schools and primary schools. Yet the diversity of American communities and of American life in general makes equally imperative some degree of variety in curricula. And whatever the limits placed on education by the demands of diversity and uniformity, there are also requirements for productivity to be met: are we producing enough scholars, scientists, poets, lawmakers, to meet the demands of our times? Moreover, schools must also contribute to the social and emotional development of the child if they are to fulfill their function of education for life in a democratic community and for fruitful family life. If the emphasis in what follows is principally on the intellectual side of education, it is not that the other objectives of education are less important.

We may take as perhaps the most general objective of education that it cultivate excellence; but it should be clear in what sense this phrase is used. It here refers not only to schooling the better student but also to helping each student achieve his optimum intellectual development. Good teaching that emphasizes the structure of a subject is probably even more valuable for the less able student than for the gifted one, for it is the former rather than the latter who is most easily thrown off the track by poor teaching. This is not to say that the pace or the content of courses need be identical for all students—though, as one member of the Conference put it, "When you teach well, it always seems as if seventy-five per cent of the students are above the median." Careful investigation and research can tell us wherein differences must be introduced. One thing seems clear: if all students are helped to the full utilization of their intellectual powers, we will have a better chance of surviving as a democracy in an age of enormous technological and social complexity.

The chapters that follow will be found to be somewhat specialized in the direction of the sciences and mathematics and how they might best be taught. This should not be taken as a declaration in favor of emphasizing the sciences and scientific training. It is an accident, rather, of historical developments over the last ten years. There has simply been more opportunity to examine progress in these fields, since it is in these fields that most of the experimental curricula have been constructed. Redoubled efforts are essential in the social studies, in the humanities, and in language instruction. A sense of tragedy and triumph achieved through the study of history and literature is surely as important to modern man as a sense of the structure of matter achieved through the study of physics. It should be utterly clear that the humanities, the social studies, and the sciences are all equally in need of imaginative effort if they are to make their proper contribution to the education of coming generations.

The top quarter of public school students, from which we must draw intellectual leadership in the next generation, is perhaps the group most neglected by our schools in the recent past. Improvements in the teaching of science and mathematics may very well accentuate the gaps already observable between talented, average, and slow students in these subjects. Even as they now exist, these gaps raise difficult problems. It is plain that, in general, scientific and mathematical aptitudes can be discovered earlier than other intellectual talents. Ideally, schools should allow students to go ahead in different subjects as rapidly as they can. But the administrative problems that are raised when one makes such an arrangement possible are almost inevitably beyond the resources that schools have available for dealing with them. The answer will probably lie in some modification or abolition of the system of grade levels in some subjects, notably mathematics, along with a program of course enrichment in other subjects. Questions about the enrichment and the special handling of gifted students will doubtless persuade the more enlightened and wealthier schools to modify current practices. But we can certainly ill afford as a nation to allow local inadequacies to inhibit the development of children born into relatively poor towns or regions.

Four themes are developed in the chapters that follow. The first of these has already been introduced: the role of structure in learning and how it may be made central in teaching. The approach taken is a practical one. Students, perforce, have a limited exposure to the materials they are to learn. How can this exposure be made to count in their thinking for the rest of their lives? The dominant view among men who have been engaged in preparing and teaching new curricula is that the answer to this question lies in giving students an understanding of the fundamental structure of whatever subjects we choose to teach. This is a minimum requirement for using knowledge, for bringing it to bear on problems and events one encounters outside a classroom—or in classrooms one enters later in one's training. The teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the classic problem of transfer. There are many things that go into learning of this kind, not the least of which are supporting habits and skills that make possible the active use of the materials one has come to understand. If earlier learning is to render later learning easier, it must do so by providing a general picture in terms of which the relations between things encountered earlier and later are made as clear as possible.

Given the importance of this theme, much too little is known about how to teach fundamental structure effectively or how to provide learning conditions that foster it. Much of the discussion in the chapter devoted to this topic has to do with ways and means of achieving such teaching and learning and with the kinds of research needed to help in preparing curricula with emphasis on structure.

The second theme has to do with readiness for learning. Experience over the past decade points to the fact that our schools may be wasting precious years by postponing the teaching of many important subjects on the ground that they are too difficult. The reader will find the chapter devoted to this theme introduced by the proposition that the foundations of any subject may be taught to anybody at any age in some form. Though the proposition may seem startling at first, its intent is to underscore an essential point often overlooked in the planning of curricula. It is that the basic ideas that lie at the heart of all science and mathematics and the basic themes that give form to life and literature are as simple as they are powerful. To be in command of these basic ideas, to use them effectively, requires a continual deepening of one's understanding of them that comes from learning to use them in progressively more complex forms. It is only when such basic ideas are put in formalized terms as equations or elaborated verbal concepts that they are out of reach of the young child, if he has not first understood them intuitively and had a chance to try them out on his own. The early teaching of science, mathematics, social studies, and literature should be designed to teach these subjects with scrupulous intellectual honesty, but with an emphasis upon the intuitive grasp of ideas and upon the use of these basic ideas. A curriculum as it develops should revisit these basic ideas repeatedly, building upon them until the student has grasped the full formal apparatus that goes with them. Fourth-grade children can play absorbing games governed by the principles of topology and set theory, even discovering new "moves" or theorems. They can grasp the idea of tragedy and the basic human plights represented in myth. But they cannot put these ideas into formal language or manipulate them as grownups can. There is much still to be learned about the "spiral curriculum" that turns back on itself at higher levels, and many questions still to be answered are discussed in Chapter 3.

The third theme involves the nature of intuition—the intellectual technique of arriving at plausible but tentative formulations without going through the analytic steps by which such formulations would be found to be valid or invalid conclusions. Intuitive thinking, the training of hunches, is a much-neglected and essential feature of productive thinking not only in formal academic disciplines but also in everyday life. The shrewd guess, the fertile hypothesis, the courageous leap to a tentative conclusion—these are the most valuable coin of the thinker at work, whatever his line of work. Can school children be led to master this gift?

The three themes mentioned so far are all premised on a central conviction: that intellectual activity anywhere is the same, whether at the frontier of knowledge or in a third-grade classroom. What a scientist does at his desk or in his laboratory, what a literary critic does in reading a poem, are of the same order as what anybody else does when he is engaged in like activities—if he is to achieve understanding. The difference is in degree, not in kind. The schoolboy learning physics *is* a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else. The "something else" usually involves the task of mastering what came to be called at Woods Hole a "middle language"—classroom discussions and textbooks that talk about the conclusions in a field of intellectual inquiry rather than centering upon the inquiry itself. Approached in that way, high school physics often looks very little like physics, social studies are removed from the issues of life and society as usually discussed, and school mathematics too often has lost contact with what is at the heart of the subject, the idea of order.

The fourth theme relates to the desire to learn and how it may be stimulated. Ideally, interest in the material to be learned is the best stimulus to learning, rather than such external goals as grades or later competitive advantage. While it is surely unrealistic to assume that the pressures of competition can be effectively eliminated or that it is wise to seek their elimination, it is nonetheless worth considering how interest in learning per se can be stimulated. There was much discussion at Woods Hole of how the climate in which school learning occurs can be improved, discussion that ranged over such diverse topics as teacher training, the nature of school examinations, the quality of a curriculum. Chapter 5 is devoted to this set of problems.

While there was considerable discussion at Woods Hole of the apparatus of teaching—films, television, and audio-visual aids, teaching machines, and other devices that a teacher may use in instruction—there was anything but consensus on the subject. Virtually all of the participants agreed that not teaching devices but teachers were the principal agents of instruction, but there was a division of opinion on how the teacher was to be aided. The disagreement, perhaps, can be summarized (though oversimplified in the process) in terms of the relative emphasis placed upon the teacher as such and upon the aids that the teacher might employ. The two extreme positions—stated in exaggerated form—were, first, that the teacher must be the sole and final arbiter of how to present a given subject and what devices to use, and, second, that the teacher should be explicator and commentator for prepared materials made available through films, television, teaching machines, and the like. The implication of the first extreme position is that every effort should be made to educate the teacher to a deep knowledge of his or her subject so that he or she may do as good a job as possible with it, and at the same time the best materials should be made available for the teacher to choose from in constructing a course that meets the requirements of the syllabus. The other extreme implies a massive effort to prepare films, television programs, instructional programs for teaching machines, and so on, and to teach the teacher how to use these with wisdom and understanding of the subject. The debate is sufficiently intense and its implications for a philosophy of education sufficiently great that the concluding chapter is devoted to this issue.

In sum, then, we shall concentrate on four themes and one conjecture: the themes of structure, readiness, intuition, and interest, and the conjecture of how best to aid the teacher in the task of instruction.