TEACHING MACHINES AND PROGRAMMED LEARNING

a source book

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DEPARTMENT OF AUDIO-VISUAL INSTRUCTION
NEA

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DEPARTMENT OF AUDIO-VISUAL INSTRUCTION
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FOREWORD

In April of 1959, A. A. Lumsdaine and I met for an informal talk in Pittsburgh. Neither of us, I am sure, had any idea that, at the end of our session, we would have launched the publication of a major book such as this one. During the course of our conversation I inquired as to the latest information on teaching machines—particularly how to obtain certain papers I was interested in reading. This interest, by the way, had been stimulated two years before by Dr. Lumsdaine's insistence on the importance of the teaching machine movement in the general development of what we had been calling "educational automation." Up to that point, sometime in 1957, the emphasis had rested entirely on the devices of mass instruction—television, mass-presented films, etc.

It had been difficult to get at the widely scattered literature on self-instructional devices. As is indicated in the introduction to the first section, this literature rested partly in Armed Forces reports, partly in unpublished papers which were duplicated and passed around from hand to hand. In answer to my query (as to where I could obtain some of these papers) Dr. Lumsdaine indicated that he and Robert Glaser had gathered a number of them together and had been thinking about the possibility of producing "some sort of a book of readings on teaching machines."

At that point in the conversation, the idea that resulted in this book was born and, insofar as I could speak as President-Elect, the Department of Audio-Visual Instruction of the NEA had added a new book to its publication list—a book of readings on teaching machines and programmed learning. The message was carried to Anna Hyer, the Executive Secretary of DAVI and Director of the Division of Audio-Visual Instructional Services of the NEA. She efficiently put the project in motion and now, a little over a year later, you have the result before you.

It is entirely fitting that DAVI should publish this book. Our members are technologists of the teaching profession. In his work, the practicing audio-visual director now worries about many kinds of "teaching machines"—motion picture projectors, cameras, television, tape recorders, etc. He also worries about "program" materials—films, filmstrips, tapes, TV programs. It is highly probable that, as the new teaching machines and their

accompanying programs move out of the laboratory into everyday instructional use, many recurring problems of utilization, teacher education, scheduling, and even service will be dropped into the audio-visual director's lap.

Further, at the college and university level, audio-visual specialists must study and solve problems dealing with teaching machines and programmed learning. This may be due to the fact that audio-visual specialists at these levels are responsible for a wide variety of activities. Some are administrators operating complex service centers and production programs; others are engaged in teacher education and the training of other audio-visual specialists; others may do some of both and, in addition, undertake research. Within these patterns, teaching machines have already appeared. Furthermore, the boundaries of the A-V specialization are varied and shifting and interlock with several disciplines. It is no accident that the links between the audio-visualist and the experimental psychologist have been strengthened through a short but vigorous tradition. Lashley and Watson inaugurated experiments on film research; throughout the years this connection has been maintained. Hoban, for example, took his degree in educational psychology and has carried this orientation throughout his many contributions to audio-visual research. Much of the research on audio-visual media has been done by psychologists—Beck, Carpenter, Freeman, Gibson, and Lumsdaine are only a few names on the list. As an examination of the papers contained in this book will show, the development of self-instructional devices has primarily been in the hands of experimental and applied psychologists. Somewhere in the process, if history is a guide, some of these psychologists will tend to become audio-visual media specialists and some audio-visual specialists will become applied psychologists. Thus, we find Douglas Porter making an analysis of audio-visual devices in relation to a discussion of teaching machines.

Psychology does not represent the only ambiguous boundary of the audio-visual education field. Another tradition—just as strong as the psychological—binds us to the applied areas of curriculum and instruction. Again, this is easy enough to establish: W. W. Charters, one of the great curriculum leaders of a generation ago, left an indelible mark on the audio-visual field—this is the tradition of Edgar Dale and Max Corey. And curriculum and instruction, as fields within the general discipline

of education, are intimately related to the problems of programming—the core of the teaching machines development.

The teaching machines described by the papers in this book are but a beginning, and the programs presented and discussed will, one day, be considered crude and unsophisticated. Some audio-visual specialists, misunderstanding, perhaps, the role of their own specialty in education, publicly worry because most of the programming so far studied has been verbal instead of pictorial. However, some of the work too recent to have found its way to publication in these pages does center around pictorial or "audio-visual" programming—for example, Keislar's use of a slide and tape machine. The issue is not verbal vs. pictorial; rather, the issue is simply that we are finally developing an instructional technology and, in that technology, self-instructional devices are going to play an increasingly important part.

If the audio-visual movement has done nothing else for American education in the fifty years of its modern development, it has attempted to improve instruction by creating, testing, and selling a gradually improving instructional technology. The days of selling have, to a large degree, disappeared. In the meantime, the technology is growing faster and faster. The audio-visual professional, as a technologist of the teaching profession, must relate to fields like psychology exactly as the medical doctor relates to his basic sciences. This interaction, I might add, is just as important for the basic scientist as for the practitioner. This is why there is much nurture for psychologists and educators alike in TEACHING MACHINES AND PROGRAMMED LEARNING.

The Department of Audio-Visual Instruction, in publishing this book, is attempting to discharge its duty to its membership, to the profession of education as a whole, and to the basic disciplines that support the profession. We have been able to do this only through the unstinting efforts of Arthur A. Lumsdaine and Robert Glaser and the support given them by the Department in the persons of Anna Hyer and Robert Snider. We are grateful, and I know that the profession will be, too.

James D. Finn, Professor of Education, University of Southern California, and President, Department of Audio-Visual Instruction

Whittier, California
June 1960

PREFACE

This volume represents the work of many contributors, to whom we should like to express our appreciation for kindly granting permission to reproduce their papers and, especially, for the tolerance they showed in permitting editorial revisions, annotations, and condensations. Special thanks are due to Sidney L. Pressey who, in addition to preparing one paper expressly for inclusion in the volume, gave generously of his time in editing a number of his previous papers and in preparing abstracts of some of the studies of his students. Our special appreciation is also due to the several other authors who wrote papers specifically for this volume or did substantial rewriting of their papers at our request.

The major task we faced as editors was that of selecting, organizing, and editing the material to provide both a comprehensive source document and a reasonably representative picture of past and current developments. The orientation and pattern of organization which we have utilized in preparing the book was influenced by numerous discussions with colleagues at the American Institute for Research and the University of Pittsburgh with whom we were working concurrently on related research projects. These include David Angell, L. J. Briggs, James L. Evans, George L. Gropper, Robert B. Hessert, Lloyd E. Homme, David J. Klaus, Harris H. Shettel, and Charles J. Stelter, to whom we are indebted for ideas which helped guide our work. We should particularly like to express our gratitude to Lloyd Homme, whose early enthusiasm and continued work in programmed learning did much to motivate our interest in this field, and to David Klaus, who has provided a critical sounding board for many of the notions which we discussed in relation to the preparation of the volume. Many of these notions, of course, stem directly from the writings of B. F. Skinner and from the earlier work of S. L. Pressey. The book was put together and the editing was done at the American Institute for Research, and we wish to express our appreciation to the Institute and, in particular, to Dr. John C. Flanagan for his encouragement of our efforts on this project.

During the period when the book was being prepared, both of the Editors were actively engaged on several research projects

concerned with teaching-machine programs and with methods of training and education, under sponsorship of the United States Office of Education, the Air Force Office of Scientific Research, the Air Force Cambridge Research Center, and the Office of Naval Research. Many of the ideas and concepts which influenced the organization and editing of the volume grew out of this concurrent work. In a less direct way our thinking has also been influenced by related work in which we previously participated over a period of years under the sponsorship of various agencies, particularly the projects sponsored by the Office of Naval Research and the Air Force Personnel and Training Research Center.

A number of the original studies reported by contributors to this volume also received direct support from the Office of Naval Research, agencies of the Air Research and Development Command of the U. S. Air Force, the U. S. Office of Education, and a number of other agencies including HumRRO (Department of the Army), the Ford Foundation and the Fund for the Advancement of Education, and several industrial organizations. Acknowledgement should also be made of the support and encouragement provided on several of these projects by the University of Pittsburgh, Harvard University, and a number of other academic institutions.

Appreciation is also expressed for permission given by publishers to reprint previously published papers in this book. These publishers include the American Psychological Association, (*Contemporary Psychology, Journal of Educational Psychology,* and *Journal of Experimental Psychology*), *School and Society, Transactions of the Kansas Academy of Science, The Journal of Experimental Education, Journal of Psychology,* the Ohio State University Press, the University of Pittsburgh Press, *Harvard Educational Review, Science, Harvard Graduate School of Education Association Bulletin,* Educational Testing Service, *Educational and Psychological Measurement, Psychological Reports, IRE Transactions on Education, Education and Commerce, Engineering and Science Monthly, Journal of Engineering Education, Audio-Visual Communication Review,* the System Development Corporation, and the Wright Air Development Division of the Air Research and Development Command.

We particularly wish to acknowledge the extensive use made in Appendix I of bibliographic annotations prepared by Edward

B. Fry, Glenn L. Bryan, and Joseph W. Rigney in "Teaching Machines: An Annotated Bibliography" under the sponsorship of the Office of Naval Research and subsequently published in the *Audio-Visual Communication Review*. We are indebted to A. W. Bendig for providing technical advice on a portion of the manuscript. Thanks for provision of photographic material is extended to S. L. Pressey, B. F. Skinner, Gil Cortlett, Duette Photographers, the Department of Photography of Ohio State University, the Rheem-Califone Corporation, Western Design (U. S. Industries, Inc.), Bell Telephone Laboratories, Inc., and other organizations.

For their help in the preparation of the manuscript and the checking of references and proof, we should like to thank all of the members of the staff of the American Institute for Research and the Department of Psychology of the University of Pittsburgh who assisted in these matters. We particularly wish to indicate our thanks for the extensive work done on the manuscript by Caroline Marchese, Mary Lou Mentzer, and Kaye Hamilton. Louis Weisz was especially helpful in checking the final page proofs.

This volume could never have been produced without the very generous support of the Department of Audio-Visual Instruction of the National Education Association. The editors wish to express their warm appreciation for the support and encouragement given by Anna L. Hyer, Executive Secretary of DAVI, Robert C. Snider, DAVI Assistant Executive Secretary, and James D. Finn, DAVI President. Dr. Snider's constant cooperation and capable handling of numerous administrative details was an essential factor in the completion of the work. Special thanks are due to Gertrude Warner of the NEA Publications Division for her work in handling the final phases of checking the manuscript and readying the proofs for the printer, and to Beth Nelson who, over the entire period during which the book was being produced, worked closely with the Editors for long hours in coordinating the many details incident to the publication and supervised the preparation of proofs and bibliographic material, as well as lending a helping hand in many other respects.

A. A. Lumsdaine
Robert Glaser

Pittsburgh
July 1960

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PART I

Purpose and Scope of This Book

THE PURPOSE of this book is to provide a comprehensive reference source on teaching machines and the techniques of instruction that are associated with them. Teaching machines and related self-instructional devices have attracted increasingly wide attention in the past few years as new media of instruction. Much of this attention has centered on the nature of specific devices for presenting instructional materials to the individual learner; however, the organization or programming of the subject matter these devices are designed to present has received somewhat less public attention. This volume deals with both of these highly interrelated aspects of an evolving educational technology, and its title—TEACHING MACHINES AND PROGRAMMED LEARNING—is intended to reflect this dual emphasis.

Although the first devices that we would today call "teaching machines" appeared over 30 years ago, they attracted relatively little attention for more than two decades. Recently, however, interest has suddenly become widespread, and developments have been occurring at a greatly accelerated rate. This upsurge of interest has created a demand for a convenient and comprehensive source of information on what has been happening and what has been written in this rapidly expanding field.

Educators and psychologists, in increasing numbers, have been seeking information about activities in this field. This effort has encountered considerable difficulty because of the relative inaccessability of much of the material. Published articles in this field have appeared in a widely scattered periodical literature. A number of the more recent contributions have not been published. Dissemination of information has depended largely on word of mouth and personal correspondence. This has been a quite inefficient process, involving much overlapping of effort, and has also imposed a heavy burden upon the authors of papers.

Available supplies of reprints or copies of unpublished papers have frequently been exhausted.

Many individuals have independently compiled bibliographies and private collections of published and unpublished papers. Several annotated bibliographies have recently been given limited distribution in mimeographed form (e.g., Darby, 1959; Fry, Bryan, and Rigney, 1960). The only published book to appear on this subject thus far is limited to papers and abstracts prepared for a symposium at the University of Pennsylvania sponsored by the Air Force Office of Scientific Research (E. H. Galanter, editor. *Automatic Teaching: The State of the Art.* New York: John Wiley & Sons, 1959). Of necessity, this collection does not provide access to original background sources that would afford broad coverage and perspective.

The present volume does not undertake to present a systematic treatise on teaching machines and programmed learning. In the opinion of the editors, such an effort, in all likelihood, would be premature at this time. Rather, this book is what its subtitle indicates: a *source book* of original papers that the student of the new field will want to consult. The major aim of this publication is simply to bring together these widely scattered reference sources and to make them conveniently available in a single volume. However, an attempt has been made to structure the field as much as possible by organizing the papers collected here in terms of the main lines of development leading up to the present state of the art.

The editors have sought to include most of the basic publications of leaders in the development of teaching machines and self-instructional learning programs. These articles span the field from the first pioneering paper published by Sidney L. Pressey in 1926 up to interim reports on present ongoing projects. Those papers that represent major landmarks of historical or systematic importance have, in general, been reprinted without editorial condensation. Some of the other reports have been edited in varying degrees to eliminate redundant portions or to delete peripheral material. One systematic exclusion has been the omission of those papers which are included in the recent collection of symposium papers edited by Galanter, since these are now readily available. However, abstracts of these papers have been included in Appendix I. In choosing among papers of

the many recent contributors to the field, the editors have been faced with a difficult task of selection. A number of individuals have recently prepared excellent papers summarizing past developments and interpreting or discussing these. Limitations of space alone have prohibited the inclusion of all these recent summaries. Moreover, the newness of the field understandably has resulted in a high degree of overlap among these papers in their summarization of past work. However, available papers which for these and other reasons have not been included in the text of the volume have been abstracted in Appendix I.

In Appendix I the editors have endeavored to identify all published papers known to them that deal directly with teaching machines and programmed learning. Also abstracted here are a number of papers that have been presented at symposia or that have been reproduced as reports or memoranda by government agencies and other institutions, without general publication. The editors have felt that the newness of the field and the rapidity with which it is developing make it useful to abstract such informally circulated papers, some of which have been cited in published articles.

This volume has been organized in five parts. In Part I the editors have attempted to provide a preliminary overview and survey of developments by including two recent reviews. The first of these, adapted from a recent article by Lumsdaine, identifies basic characteristics common to all devices currently classed as teaching machines. It illustrates these characteristics by describing a number of devices that have been developed and also provides a brief characterization of some of the techniques of programming materials for use in various devices. The other introductory paper reprints a recent review by Glaser, in which he has viewed current and past developments in historical perspective. In this review, the necessity for improvement in educational technology has been related to the promise that the evolution of the teaching machine may hold for meeting this need. This has been done by a review of several key articles. These represent, first, the pioneering contributions of Sidney L. Pressey; second, the recent leadership and major contributions to the field provided by B. F. Skinner; and, third, some speculations about the future of education in an increasingly technological society as projected by Simon Ramo.

The original papers, representing the basic source material of this book, have been grouped in four parts which reflect the major lines of development in the field. Part II begins with the early work initiated by Pressey 35 years ago, which for some years went generally unrecognized. This section reports work along the lines initiated by Pressey, continuing up to the mid-fifties. Part III presents the basic articles of Skinner, who in 1954 pointed out that his previous work on the analysis of behavior was applicable to the development of teaching machines. This section includes work that has continued under his general guidance up until the present time. Part IV contains contributions, from a variety of sources, which are related to the theme of this volume but which are not directly continuous with the work of Pressey and Skinner. A number of the articles in Part IV grew out of the work of experimental psychologists on problems of training and instruction in the military services. Part V represents a sample of recent activities and current trends of thinking on teaching machines and programmed learning, which have been largely stimulated by the work of Skinner and his associates.

For each of these major parts of the book, the editors have provided a brief introduction that describes some general characteristics of each group of papers, notes significant features of individual papers, and seeks to provide a useful perspective. Throughout the text, references are provided to related papers which have not been reprinted in full but which have been abstracted in Appendix I. (In Appendix I no internal structuring in terms of chronology or line of development has been used; to facilitate search, abstracts of papers or annotated titles are presented in straight alphabetical order by author and year.)

One systematic editorial change has been made in all the papers for the convenience of the reader; namely, references to published literature contained in footnotes or bibliographic lists in the original articles have been reduced to a common style of reference, and the frequently overlapping bibliographies in the original papers have been collected in one comprehensive reference list at the end of the volume. Reference citations in the text are made by author and date, so that these can be readily located in the single reference list (Appendix II).