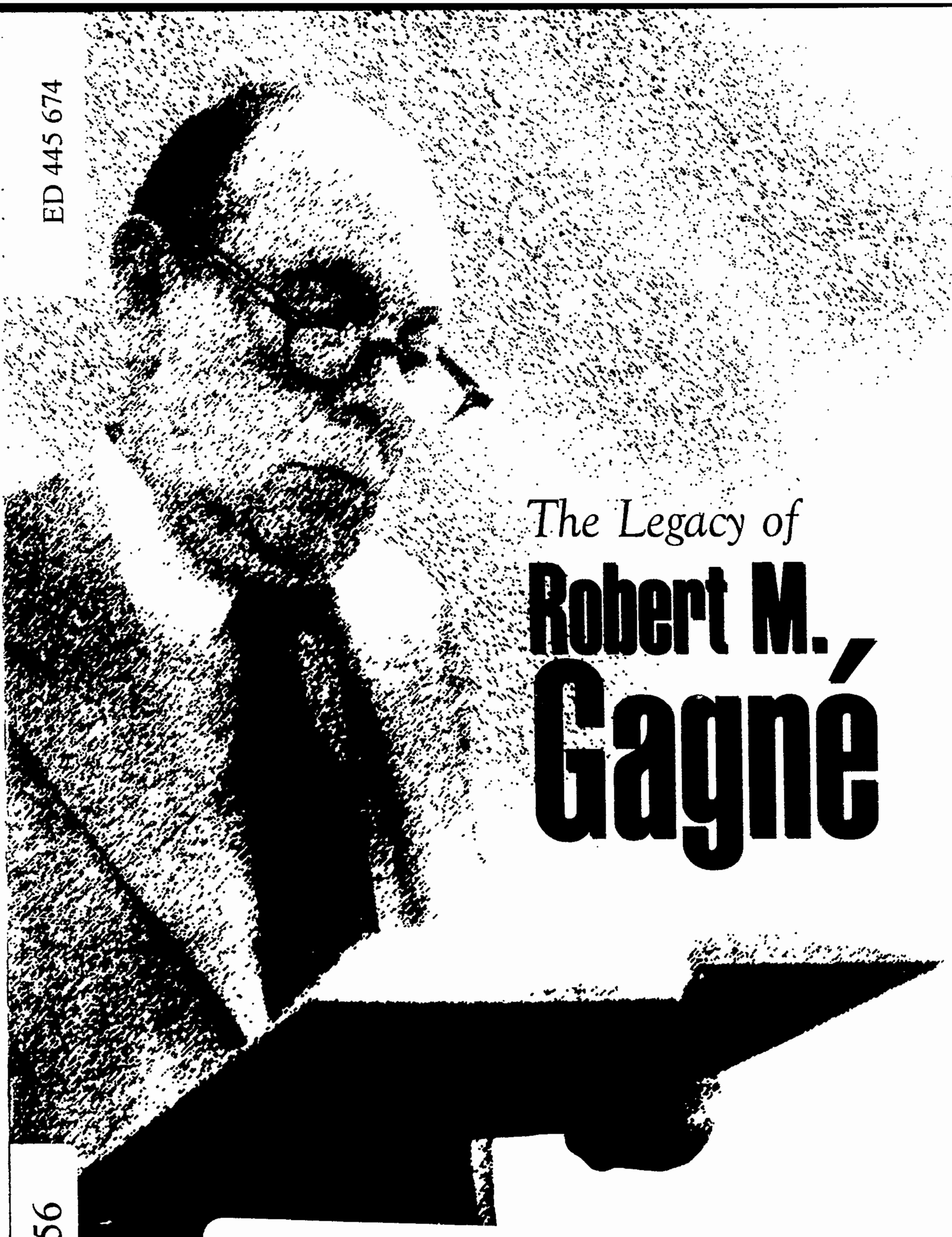
DOCUMENT RESUME

ED 445 674 IR 020 356

AUTHOR	Richey, Rita C., Ed.
TITLE	The Legacy of Robert M. Gagne.
INSTITUTION	ERIC Clearinghouse on Information and Technology, Syracuse, NY.
SPONS AGENCY	Office of Educational Research and Improvement (ED), Washington, DC.
REPORT NO	IR-108
ISBN	ISBN-0937597-49-X
PUB DATE	2000-00-00
NOTE	295p.
CONTRACT	ED-99-CO-0005
AVAILABLE FROM	ERIC Clearinghouse on Information & Technology, Syracuse University, 621 Skytop Rd., Suite 160, Syracuse, NY 13244-5290 ($20). Tel: 315-443-3640; Tel: 800-464-9107 (Toll Free); Fax: 315-443-5448; e-mail: eric@ericir.syr.edu.
PUB TYPE	Books (010) -- Collected Works - General (020) -- ERIC Publications (071)
EDRS PRICE	MF01/PC12 Plus Postage.
DESCRIPTORS	Constructivism (Learning); *Educational Technology; *Educational Theories; Elementary Secondary Education; Futures (of Society); *Instructional Design; Postsecondary Education
IDENTIFIERS	*Gagne (Robert M)

ABSTRACT

This book highlights and discusses the contributions of Robert M. Gagne to the field of instructional technology. Section One presents the core concepts of Gagne's theory and contains reprints of the following five journal articles by Gagne: "Contributions of Learning to Human Development," "Learning Hierarchies," "Domains of Learning," "Mastery Learning and Instructional Design," and "Integrative Goals for Instructional Design." Sections Two analyzes the influence of Gagne's ideas from a variety of perspectives, including the following articles: "The Impact of R.M. Gagne's Work on Instructional Theory" (Patricia L. Smith and Tilman J. Ragan); "The Impact of Gagne's Theory on Instructional Design Practice" (Dennis C. Fields); "Gagne's Influence on Military Training Research/Development" (J. Michael Spector); and "Gagne and the New Technologies of Instruction" (Wayne A. Nelson). The article comprising Section Three, "The Future Role of Robert M. Gagne in Instructional Design" (Rita C. Richey), speculates on the extent to which Gagne's work will continue to influence the field of instructional technology in the future, even with the growing influence of constructivist approaches to instruction. Each article contains references. Appendices include: the American Psychological Association Scientific Award for the Application of Psychology, 1983; a bibliography of publications by Gagne; and information about ERIC. Includes Subject and author indexes. (MES)



The Legacy of

Robert M. Gagné

edited by

Rita C. Richey

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IR-108

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This publication is available from Information Resources Publications, ERIC Clearinghouse on Information & Technology, Syracuse University, 621 Skytop Road, Suite 160, Syracuse, NY 13244-5290; 1-800-464-9107 (IR-108)

This monograph is co-published with the International Board of Standards for Training, Performance and Instruction (ibstpi).

ISBN: 0937597-49-X

U.S. Department of Education
Office of Educational Research and Improvement
National Library of Education

This product was funded in part with Federal funds from the U.S. Department of Education under contract no. ED-99-CO-0005. The content of this publication does not necessarily reflect the views or policies of the U.S. Department of Education nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. government. The U.S. Department of Education's web address is: http://www.ed.gov

Editors: R. D. Lankes, Eric Plotnick, Susann L. Wurster
Designer: Lloyd Lathrop

Published: 2000, Syracuse, New York.

Dedication

This book is dedicated to Robert M. Gagné, in appreciation of his work and the contributions he has made to the field of Instructional Technology. We thank you.

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Foreword

Ideas often take a substantial amount of time to be appreciated, and even for those few that attract attention quickly, there is an assumption that one needs the perspective of hindsight to determine their lasting value. Consequently, an intellectual inheritance is usually determined by the survivors rather than by the donor, and the labels that describe the merit of one's ideas are affixed by subsequent generations. While this may be the norm, it is not the case with respect to the contributions of Robert Gagné to the field of Instructional Technology. While the field will more fully understand the extent of Gagné's genius as time passes, it is still easy to recognize that this field would be entirely different today if it were not for the work of Robert Gagné. His legacy can be determined now, at least in part. This volume is an attempt to highlight, discuss, and celebrate (even as we evaluate) the contributions of this one man.

Edward Thorndike once said that he expected a usual lag of 30 to 50 years between the time that research "discoveries" are made and their implementation in classrooms. There are many examples of situations that give credence to this observation. Yet much of Gagné's research has not only impacted practice in many settings, but it has established the norm during his lifetime.

Gagné's work is unique in the extent to which it has actually shaped an entire field. He has influenced theory and practice, teaching and research, school and non-school environments. Today we marvel at the emerging capabilities of technology and the possibility these technologies afford teaching and learning, and yet the mind of Robert Gagné has expanded the scope and contributions of this field in much the same fashion as has the computer.

This book has three major sections dealing with the ideas, the impact, and the future. The preface is a critical precursor to each of these sections, establishing a personal context for a discussion and analysis of Gagné's work by presenting a picture of Robert Gagné, the man. It is written by Walt Wager and Marcy Driscoll, who worked closely with Gagné in the same academic department, and who collaborated with him on major scholarly projects. They write as individuals who have known him as a friend as well as a co-worker.

Section One presents the core concepts of Gagné's theory. These are reprints of five journal articles that capture the essence of the ideas he has given to the field, and present Gagné's ideas in his own words. These articles and their foundational research span nearly four decades. The first papers describe early elements of his thinking which are currently part of standard practice and theory. The last paper was originally published in 1990 and was co-authored with another giant in the field—David Merrill. This work presents new ideas that have not yet become firmly established.

Section Two analyzes the influence of Gagné's ideas from a variety of perspectives. These chapters present reflections of his impact on instructional theory, on practice in a wide range of settings, on military training research and development, and on the applications of the new technologies. They are written by a new generation of instructional technologists who "grew up" professionally at different times and in different places with the ideas of Gagné. Smith was a Florida State student during Gagné's tenure. Smith and Ragan describe and analyze the theoretical aspects of Gagné's work. They are well qualified to undertake such a task given their own work in the field, always fully grounded in theory. Fields discusses the impact of Gagné's research on design practice from both a personal and scholarly point of view. Spector's examination of Gagné's role in military research and development comes from not only a historical perspective, but also from his own memories of working with Gagné on military projects. Finally, Nelson explores current design efforts that are maximizing the opportunities afforded by the new technologies. Even though Gagné was surely not a "techie," Nelson finds that here too his influence is considerable.

Finally, in Section Three, Chapter Ten, Richey speculates upon the extent to which Gagné's work will continue to influence the field of Instructional Technology in the future even in a world with growing influence of constructivist approaches to instruction.

These ten chapters are an attempt to summarize the contributions of Robert Gagné and to assess their continuing stability. These discussions have been written at a time of rapid change in both the theory and practice of instructional design. At this time there is a peculiar situation in which Gagné's ideas, in some quarters, are so entrenched in practice that many have ceased to associate them with Gagné and instead see them as simply "the way design is done." On the other hand, there are those today who undoubtedly see these same notions as passe and actually the antithesis of the directions instructional design should be taking. Hopefully, this book will encourage an analysis and reflection upon Gagné's theoretical contributions and at the same time provide some sense of Robert M. Gagné as a human being.

The idea for this book emerged over five years ago at an International Board of Standards of Training, Performance and Instruction *(ibstpi)* board meeting. This international group promotes high standards of professional practice in the areas of training, performance and instruction, especially with respect to competency definition and certification. Although *ibstpi* is primarily associated with practitioners and the establishment of instructional design standards in the workplace, it is also dedicated to promoting research and exploration of the field's theory. The board consists of persons representing corporate training, training consultants, and academe. As such, there is an appreciation of the interdependence of theory and practice. The board hopes that the publication of this book will not only pay tribute to a major figure in Instructional Technology, but will also promote the application of design theory and, in the process, advance design practice.

Rita C. Richey
Detroit, Michigan
October, 1999

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Preface

Discussing the personal life and accomplishments of Robert M. Gagné presents a challenge. The list of accomplishments alone fills pages with bibliographic references. The personal dimension, however, is probably different for every one of us who know him–rich with stories of personal interactions. First, for anyone who has never met him, Bob Gagné is a physically big man. When you put his legacy behind him he becomes even bigger.

We both remember reading parts of early editions of *Conditions of Learning* while completing our respective doctoral programs. Walt Wager remembers meeting him for the first time at Florida State University and being somewhat in awe of a man who, along with his colleague Leslie Briggs, was defining the field of Instructional Systems. Marcy Driscoll's first encounter with Gagné came during her interview at Florida State. She recalls, "We were going to lunch, and Bob insisted on sitting in the back seat—of a small Toyota, no less. He climbed in and planted himself in the middle, with a hand on either front seat and his face squarely between. Then he asked me, 'What do you think people remember from television documentaries?' The question took me completely by surprise, and all I could think was, 'Is this a trick question?'!"

However, we soon came to know both Les and Bob. Both were very receptive to discussions of their writings and ideas, and both were looking for better ways to spread their principles of instructional systems so that others could understand and use them in teaching and the design of instruction. Wager always thought of Bob as the theoretician and researcher and Les as the practitioner, but of course each was both. Driscoll came to expect Gagné's questions as a sign of his irrepressible curiosity about things, and Briggs' futurist attitudes greatly affected her own.

For Wager, mentoring defines the professional character of Bob Gagné. Wager's first experience in working with him on a publication came after the death of Leslie Briggs, when he and Bob wrote the third edition of *Principles of Instructional Design*. Wager remembers Gagné's constructive feedback and careful use of words. "I still can't read the text of *Principles of Instructional Design* without hearing his voice phrasing the passages," says Wager. "He is still open to listening to my thoughts and theories about learning and teaching, and quick to put them into his broader perspective."

Driscoll describes a similar experience working with Gagné on the second edition of *Essentials of Learning for Instruction*. "Bob wrote faster than anyone I had ever worked with before," she recalls. "He was always a chapter ahead of me. We traded chapters to edit each other's work, and it always amazed me that he accepted most of my recommended changes. His writing is so elegant. But he was always open to my ideas."

Driscoll also had the experience of team teaching a graduate course in learning and instruction with Bob. It was a course that she would eventually take over as her own, but teaching it together with Bob Gagné was, in her words, "a rare treat." "We all loved listening to Bob talk, telling stories of how he developed his views of teaching and learning," says Driscoll. "I remember one day in particular when a student asked him how researchers develop theories or models. This was in reference to his instructional theory described in Chapter 12 in the fourth edition of *Conditions of Learning*. He thought for a minute, and then said, 'You just think it up!'"

Wager is quick to note another side of Robert Gagné, his non-vocational interests. Bob Gagné is a fine craftsman of clocks. One clock hangs in the department suite at FSU, one sits on a bookshelf in Wager's home, and one sits on the kitchen counter in Driscoll's home. Bob is also interested in computers and has solicited Wager's help in buying, setting up, and using the machines. Now, one doesn't have to be around Bob very long to learn that he has little tolerance for mechanical devices that don't work. We have seen phones fly along with expletives damning their creators and keepers. So you may imagine the task, for instance, of getting a modem connection to work with e-mail where anything can go wrong (and generally does). However, Bob is now surfing the Internet via delphi.com.

Robert M. Gagné is a no-gimmicks, down-to-earth, back-to-basics type of person. He believes that educational systems let their patrons down when they promote students from grade to grade, who can't read, write, or do arithmetic. The issue of teaching higher-order thinking skills and meta-cognitive skills, he believes, depends upon these basic building blocks. These are very emotional topics for Bob Gagné, and he has deep beliefs about what a good education is. Chapters in this book will go into these beliefs and principles in greater detail.

Certainly no documentary of Bob Gagné would be complete without recognizing the influence of his wife Pat. Pat is a trained biologist and a professional in her own right. She is also a steadying and supportive influence on Bob. Anyone visiting with both of them quickly sees a mutual love and respect that goes very deep.

The chronicle of the life and achievements of Bob Gagné may be found in Appendix A. This is a reprint of the American Psychological Association's 1982 scientific award for applications of psychology. Appendix B lists Gagné's publications. Gagné had so many publications, awards and recognitions, we are sure that these records may not be complete. Any one of the awards mentioned would be lifetime achievements for most of us. To have amassed so many speaks to the unrelenting productivity of this great man and educator.

Robert M. Gagné received many awards during his career, including membership in Phi Beta Kappa, Sigma Xi, and the National Academy of

Education. He was awarded an Eminent Lectureship Award by the Society of Engineering Education, American Educational Research Association (AERA)—Phi Delta Kappa Award for Distinguished Educational Research, the E.L. Thorndike Award in Educational Psychology and the John Smyth Memorial Award, Victorian Institute of Educational Research. He received Florida State University's highest award, the Robert O. Lawton Distinguished Professorship, and the American Psychological Association (APA) Scientific Award for Applications of Psychology.

Gagné left Tallahassee in 1992 to spend a year and a half at Armstrong Laboratories, Brooks Air Force Base, in Texas as a National Research Council Senior Fellow. There he developed and evaluated a computer-based program designed to teach a 32-step procedure used to check out the electrical system of the gun in the F-16 aircraft. He also developed an instructional videotape by applying his nine events of instruction. Application of the nine events to actual training problems at Armstrong Laboratories was Gagné's primary purpose in being there. In his words, "They [Armstrong Labs] had never used the nine events to develop instruction before. And I must say, it worked very well!"

More recent honorary awards include the *Educational Technology* Person of the Year Award, Professor Emeritus at Florida State University, and the AECT Outstanding Educator and Researcher Award. In addition, the Gagné-Briggs fellowship has been established at Florida State, and each year an outstanding doctoral and masters student in the Instructional Systems program are selected in the honor of Gagné and Briggs. Bob Gagné is now retired and living in Signal Mountain, Tennessee. His last project involved working with Dr. Karen Medsker on a new edition of *Conditions of Learning* specifically applied to workplace training. This was published in 1996.

Robert M. Gagné has had a profound influence on the fields of educational psychology and instructional systems. He has also had a profound effect on many of us as a colleague and mentor. His contributions and high standards have shaped this field and will continue to motivate us to do our best and to strive for even more.

Marcy P. Driscoll
Walter W. Wager
Tallahassee, Florida, 1999

Authors' Biographical Sketches

Marcy P. Driscoll is professor and department chair of Educational Research at Florida State University. Driscoll is the author or co-author of four textbooks in learning and instruction, including *Psychology of Learning for Instruction* (1995 Outstanding Book Award in Instructional Development from the Association of Educational Communications and Technology) and, with Robert M. Gagné, *Essentials of Learning for Instruction*. Driscoll has also published numerous articles in professional journals on learning, instructional theory, and educational semiotics. Professor Driscoll earned an A.B. magna cum laude degree from Mt. Holyoke College and a M.S. degree and a Ph.D. degree in Educational Psychology from the University of Massachusetts at Amherst.

Dennis C. Fields is professor of Information Media and director of Personnel and Program Development in the Learning Resources Services at St. Cloud State University. Fields earned a B.S. degree in Science and Education, a M.S. degree in Communication Media, a doctoral degree in Instructional Technology, and a post-doctoral major in Information Science. He has been a professional educator for 25 years in colleges and universities, as well as public schools. In addition, he has served as a consultant to numerous organizations in both the private and public sector. Currently, his work involves the design of technical skills training programs delivered via interactive technology. His publications focus upon technology administration and management. Fields is a member of the International Board of Standards for Training, Performance and Instruction.

Wayne A. Nelson is professor of Instructional Technology and chair of the Department of Educational Leadership at Southern Illinois University at Edwardsville. Nelson is currently a member of the editorial review board for the *Journal of Educational Multimedia and Hypermedia*, the *Journal of Research on Computing in Education*, and the *Journal of Educational*

Computing Research. He has conducted research and published in the areas of learning with hypermedia systems, interface design, intelligent tutoring systems, and the processes of instructional design. Computer technology to support the development of reflective practice by teacher education students is his current research focus.

Tillman J. Ragan is professor in the Instructional Psychology and Technology program at the University of Oklahoma. Ragan earned a Ph.D. in Instructional Technology from Syracuse University in 1970. He is author of five books and numerous articles in the area of Instructional Technology, most recently the text, *Instructional Design*, with P.L. Smith. He has served in countless offices and committees including President of the Research and Theory Division and of the Division of Instructional Development of AECT, Vice-President of IVLA, and Co-Chair of the Professors of Instructional Design Technology conference in 1992. His area of research and teaching is Instructional Technology, with specific interests in applications of computer technology to instruction, learner characteristics, and visual literacy.

Rita C. Richey is professor and program coordinator of Instructional Technology at Wayne State University. Richey earned a B.A. in English and M.Ed. in Psychology of Reading from the University of Michigan and a Ph.D. in Instructional Technology from Wayne State University. She has been at Wayne State in the College of Education since that time. She is the author of numerous publications including *The Theoretical and Conceptual Bases of Instructional Design* and *Designing Instruction for the Adult Learner* and co-author of *Instructional Technology: The Definition and Domains of the Field*. She is the recipient of the President's Award for Excellence in Teaching, the Board of Governor's Distinguished Faculty Fellowship, and the Outstanding Graduate Mentor Award at Wayne State University. She has also received the Outstanding Book Award in Instructional Development and the James W. Brown Publication Award from the Association of Educational Communications and Technology. Her current scholarly interests include the study of the role of context in design, the history of instructional technology thought, instructional design competency development, and instructional design research and theory. She is vice-president for Research and Development of the International Board of Standards for Training, Performance and Instruction.

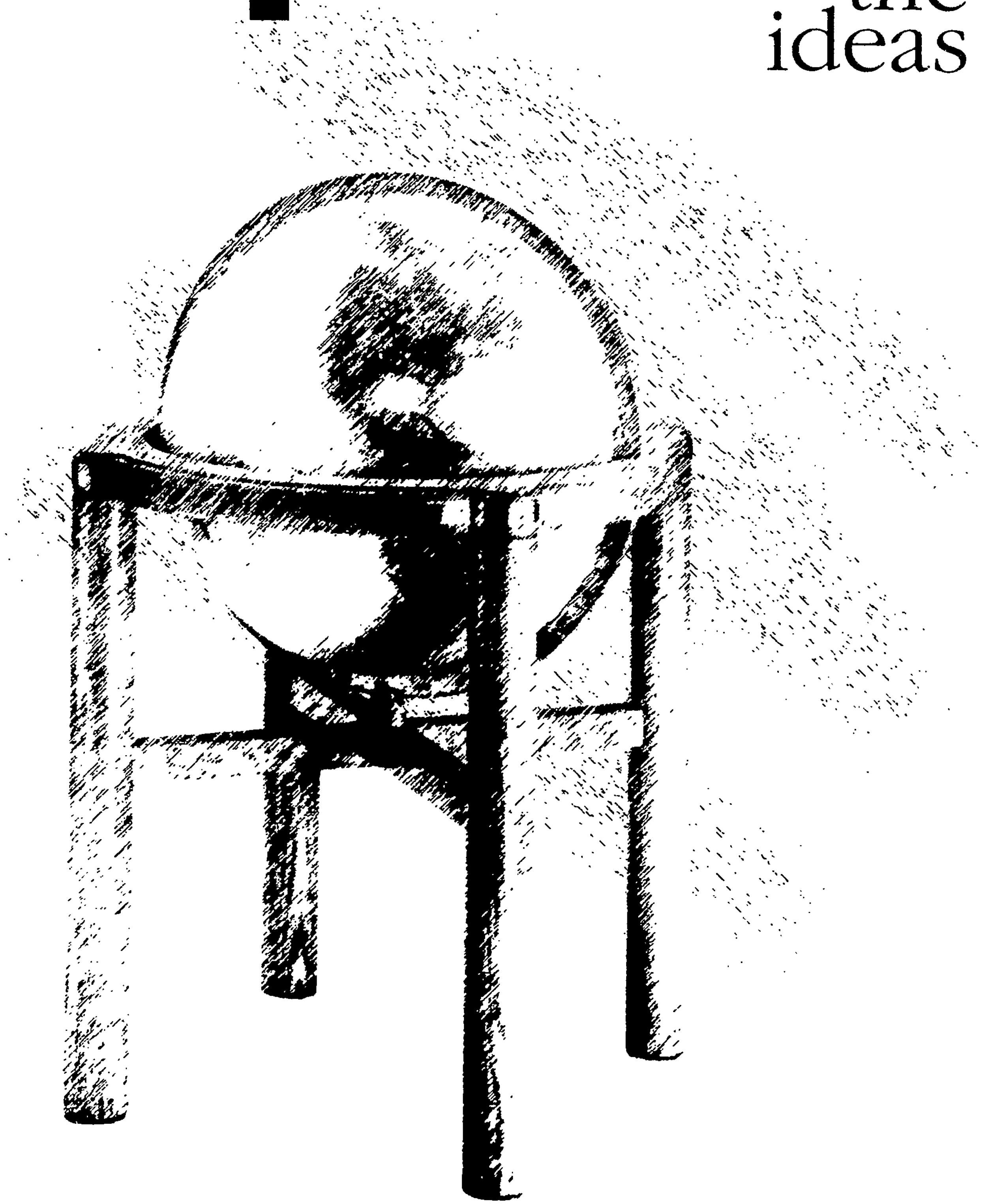
Patricia L. Smith is associate professor of Education, University of Oklahoma. Smith earned a B.S. in Elementary Education from Texas Tech University in 1972, a M.S. in Elementary Education and Reading Education from Texas Tech University in 1976, and a Ph.D. in Instructional Systems from Florida State University in 1982. She has public school teaching experience and has worked as a consultant on training design projects for business, industry, and governmental agencies. Prior to joining the University of Oklahoma faculty, she was a member of the Instructional Technology faculty at the University of Texas at Austin. She is the author of two books, numerous articles, and research technical reports. She is active in many professional organizations such as the American Educational Research Association, for which she was president of the Instructional Technology Special Interest Group, 1993-1994, and the Association for Educational Communications and Technology, for which she has served on both the Board of Directors for the Research and Theory Division and the Division of Instructional Development.

J. Michael Spector is professor and chair of Instructional Design, Development and Evaluation at Syracuse University and the Scientific Advisor for the Educational Information Science and Technology Research Program at the University of Bergen. From 1991 through 1997, Spector was the senior scientist for the United States Air Force Research Laboratory (Armstrong Laboratory) Instructional Systems Research Branch. He is a distinguished graduate of the United States Air Force Academy (1967) and earned a Ph.D. in Philosophy from the University of Texas at Austin in 1978. Before joining Armstrong Laboratory in 1991, Dr. Spector was an associate professor of Computer Science at Jacksonville State University specializing in Software Engineering and Artificial Intelligence. His recent research is in the area of intelligent performance support for instructional design and in system dynamics based learning environments. He has published numerous refereed journal articles and book chapters in the area of automated instructional design and has produced an edited volume about this emerging new area of research. He is active in professional associations and serves on the editorial boards of several international journals. He was awarded a Fulbright research fellowship (1995/1996) to work at the University of Bergen creating and testing an interactive simulation of the project dynamics for large courseware development efforts. Dr. Spector helped found and is the President of the International Consortium for Courseware Engineering. He is an adjunct member of Göteborg University's Pedagogy Faculty and Agder College's Faculty of Computer Engineering and a guest lecturer and member of the graduate faculty in the Department of Educational Psychology at the University of Minnesota. He is also the treasurer of the International Board of Standards for Training, Performance and Instruction.

Walter W. Wager is professor of Instructional Systems at Florida State University. Wager moved to Florida State University in 1972 after earning an Ed.D. degree in Instructional Technology from Indiana University. He currently teaches computer courseware, electronic performance support systems design, and instructional development. His present research interest is in the design of interdisciplinary thematic instruction, and collaborative learning. He has published numerous articles, book chapters, and three textbooks, including the *Principles of Instructional Design* with Robert Gagné and Leslie Briggs. In addition, he received the Provost's Outstanding Teacher Award at Florida State University, and the L. C. Larson Leadership Award from Indiana University. He is a member of Phi Delta Kappa, and Kappa Delta Pi honorary societies, as well as a number of other professional organizations.

section 1

the ideas



Introduction

This section consists of five journal articles published between 1968 and 1990 that briefly capture the core of Robert Gagné's theoretical contributions to the knowledge base and the practice of instructional design. These articles were published during the middle and later portions of his career, and although they are not research reports in themselves, they reflect his lifelong dedication and involvement in research. Many of the ideas presented here are rooted in Gagné's early basic research on animal and human learning, as well as the more applied research he completed in both military and civilian research environments. The later work was especially directed toward practical instructional applications, most notably in school learning and curriculum development.[1]

Each of these articles demonstrates Gagné's extraordinary ability to present complex ideas in a very simple fashion, frequently aided by his skillful use of everyday examples which "strike home" to most educators. The articles demonstrate his expertise as a scholar and his sensitivity to common concerns of teachers. They show evidence of his knowledge of the current literature of the time, and demonstrate the originality of his thinking. His frequent use of italics for emphasis and highlighting of critical ideas guides the reader, as learner, through his logic. Reading Gagné is *hearing* Gagné talk to you.

The theses of these five articles—cumulative learning theory, learning hierarchies, domains and conditions of learning, events of instruction, and enterprise schema—represent the critical dimensions of Gagné's instructional theory. The first two articles, "Contributions of Learning to Human Development" and "Learning Hierarchies," are related and were both published in 1968. They speak to the notion of how we learn,

[1] For a complete examination of Gagné's research, one should see Gagné, R. M. (1989). *Studies of Learning: 50 Years of Research.* Tallahassee, FL: Learning Systems Institute, Florida State University. This volume is a nearly complete collection of Gagné's publications with his introductory remarks that put the work into historical perspective.

especially with respect to transfer of training. Their key contributions to instructional design are a recognition of the impact of previous learning and prerequisite skills upon the sequencing of instruction, and provide the rationale for determining the most appropriate content for a given piece of instruction.

Chapter 3, the reprint of "Domains of Learning," summarizes Gagné's taxonomy of learning outcomes and the different conditions that facilitate each kind of learning. This classification scheme has been expanded in the four editions of his important book, *The Conditions of Learning*, that were published between 1965 and 1985. The central idea, however, did not change substantially during these 20 years.

These first three articles deal with over-all orientations to the task of designing instruction. The fourth article, "Mastery Learning and Instructional Design" deals with what is often called micro-design, or the design of individual lessons. It presents Gagné's nine Events of Instruction as a framework for selecting and creating effective instructional strategies and relates them to the general notion of mastery learning, a concept originally proposed by John Carroll (1963) and then operationalized by Benjamin Bloom. These nine steps, while introduced in *The Conditions of Learning*, subsequently were discussed in detail in *The Principles of Instructional Design* with Leslie Briggs and Walter Wager, and were addressed in a practical guide for classroom teachers, *Essentials of Learning for Instruction*, with Marcy Driscoll.

Finally, Chapter 5 presents the last major conceptual innovation of Robert Gagné, that of the enterprise schema. The article, "Integrative Goals for Instructional Design" written with David Merrill (1990), reflects the dominance of the cognitive psychology orientation in modern instructional design. It accommodates the more complex types of learning tasks more typical of a field that is de-emphasizing content broken down into many small component objectives. This last contribution has implications for rethinking the nature of the events of instruction, especially the stage in which the learner is informed of the objective. Now there is the suggestion that a larger "enterprise schema" should be described.

These five articles were written during a period of nearly 25 years and present an important facet of the intellectual history of not only instructional design, but of the larger field of Instructional Technology. The ideas are still challenging to educators today, even though the first articles in this series were published in a day when programmed instruction and behaviorist psychology were seen as the answer to educational innovation and reform.

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Chapter 1

Contributions of Learning to Human Development[2]

Robert M. Gagné

The following article, published during Gagné's tenure at The University of California, at Berkeley, presents his explanation of the nature of human intellectual development, cumulative learning theory. This article emphasizes the contrasts between his theory and other prominent explanations of intellectual development and his continuing concern with transfer of training. It also reflects Gagné's involvement in the development of an innovative school science curriculum. Much of the research that stimulated this position was completed during his Princeton years. Cumulative learning theory, in effect, provided alternatives to the programmed instruction orientation to instructional sequencing which was so popular at the time.

[2] *Editor's Note*: From "Contributions of Learning to Human Development," by R. M. Gagné, 1968, *Psychological Review*, 75, p.177–191. Copyright 1968 by the American Psychological Association. Reprinted with permission from American Psychological Association. This article is a slightly modified version of the Address of the Vice President, Section I (Psychology), of the American Association for the Advancement of Science. Gagné delivered this paper at the annual meeting of the Association in Washington, DC, December 1966.

One of the most prominent characteristics of human behavior is the quality of change. Among those who use the methods of science to account for human behavior are many whose interest centers upon the phenomena of behavioral change, and more specifically, on change in behavior capabilities. Sometimes, changes in behavior capabilities are studied with respect to relatively specific forms of behavior, usually over relatively limited periods of time—hours, days, or weeks. In such instances, the investigator names the processes he studies *learning and memory.* Another major class of phenomena of capability change comprises general classes of behavior observed over longer periods of time—months and years. The latter set of events is usually attributed to a process called *development.*

The reality of these two kinds of capability change is obvious in everyday experience, and requires no special experimentation to verify. The capabilities of the young child, for example, change before our eyes every day, as he learns new names for things, new motor skills, and new facts. In addition, his more general capabilities develop, over the months, as he becomes able to express his wants by means of word phrases, and later to communicate in terms of entire sentences and even longer sequences of ideas, both in oral and printed form. From these common observations one can distinguish in at least an approximate sense between the specific short-term change called learning, and the more general and long-term change called development.

To distinguish learning and development is surely a practically useful thing, for many purposes. At the same time, the two kinds of processes must be related to each other in some way. The accumulation of new names for things that the child learns is quite evidently related to the capability he develops for formulating longer and more complex sentences. The specific printed letters he learns to discriminate are obviously related to the development of his reading skills. The question is, how? What is the nature of the relation between the change called learning, on the one hand, and the change called development, on the other?

Over a period of many years, several different answers have been proposed for this question of the relation between learning and development. Investigators in this field have in general been concerned with accumulating evidence that they interpret as being consonant or dissonant with certain theories, or models. Usually the model they have in mind is fairly clear, even though it may not be explicitly represented in their writings.

Models of Human Behavioral Development

It is my purpose here to consider what certain of these models are, and what their implications are for continuing research on human learning and development. Specifically, I am interested in contrasting certain features of models that appear to be of commanding interest in present-day research. I hope by this means to clarify some issues so that they may, perhaps, be subjected to experimental testing in a manner that will allow us to sharpen and strengthen our inferences about the nature of human behavioral development.

It is inevitable that the theme of genetically determined growth, or maturation, as opposed to influences of the environment, will run through any discussion of the nature of behavioral development. Everyone will agree, surely, that development is the result of an interaction of growth and learning. There are enormous practical consequences associated with this issue—for example, in designing education for the young. If growth is the dominant theme, educational events are designed to wait until the child is ready for learning. In contrast, if learning is a dominant emphasis, the years are to be filled with systematically planned events of learning, and there is virtually no waiting except for the time required for bringing about such changes.

It will be clear enough that my own views emphasize the influence of learning, rather than growth, on human behavioral development. But this is not because I deny the importance of growth. Rather it is because I wish to come to grips with the problem of what specific contributions learning can make to development, and by inference, what kinds of learned capabilities enter into the process of development. I want particularly to contrast a model of development that attempts to account specifically for learning effects with certain other models that do not do so. When I describe this model, you will perhaps agree that it can be conveyed briefly by means of the statement: Within limitations imposed by growth, *behavioral development results from the cumulative effects of learning.*

To set the stage for a model of this sort, it seems desirable first to mention two other models that are more or less in current use, and which have been in existence for some time. The first of these may be called the *growth readiness model*, which has been associated in previous times with such theorists as G. Stanley Hall (1907) and Arnold Gesell (1928), among others. Briefly, it states that certain organized patterns of growth must occur before learning can effectively contribute to development. Major evidence for this theory comes primarily from studies of the development of physical and motor functions in young children. A prototype study in this field (Gesell & Thompson, 1929) involved special training in stair-climbing for one of a pair of identical twins at the age of 46 weeks, no special training for the other twin. At 53 weeks, the untrained twin did not climb as well as the trained twin. But after 2 weeks of training, one-third as much as the total given to the trained twin, she actually surpassed the trained twin in performance. What this and many similar studies are usually interpreted to mean is that training for a motor performance might as well wait, in fact had better wait, until the child is maturationally "ready," before beginning the specific regime of training leading to the desired proficiency. The findings are consistent with this model. Other writers have pointed out that giving the untrained twin no special training doesn't mean that the child is learning nothing during this period. Unfortunately, the study is not therefore a truly critical one for testing predictions from the theory. Actually, it must be said that much other evidence bearing upon this model suffers from this kind of defect.

A second model of considerable importance, particularly because it has attracted much attention, is that of Piaget. Although the interaction of the child with his environment is given a specific role in this theory, it is well to recognize that it is in some fundamental sense a theory which assigns only a contributory importance to the factor of learning (Flavell, 1963, p.46; Sonstroem, 1966, p.214). The model may be summarized, briefly in the following statements:

1. Intellectual development is a matter of progressive internalization of the forms of logic. The sequence of development manifests itself at first through motor action, later through concrete mediation of ideas, and still later through complete symbolic representation.
2. Progress in development is affected by the interaction of the child with his environment. New experiences are *assimilated* into existing cognitive structures, and newly acquired structures in turn make possible *accommodation* to the demands imposed by the environment. The total process, as Flavell (1963, p. 47) points out, may be considered one of *cognitive adaptation.*

This theory has been accompanied by a great mass of observational evidence, gathered over a period of many years, by Piaget and his colleagues in Geneva. They have observed childrens' performance of a variety of tasks, including those having to do with number, quantity, time, movement, velocity, spatial and geometrical relations, the operations of chance, and reasoning, among others. Generally speaking, the method has been to present the child with a concrete situation, say, two arrays of beads differing in spatial arrangement, and to ask probing questions in the attempt to determine the nature of the child's understanding of the situation. The behavior of the same child may then be tested again at a later age; or his behavior may be compared with that of older children on the same task.

There have been a number of confirming studies of Piaget's findings carried out by several investigators in various countries of the world (Dodwell, 1961; Elkind, 1961; Lovell, 1961; Peel, 1959). More important for present purposes, however, are the several studies that have attempted to induce particular kinds of intellectual development by means of specific instruction (or learning). Many of these are described by Flavell (1963, p.370 ff.), and need not be reviewed here. One prototype investigation, by Wohlwill and Lowe (1962), took the following form: Kindergarten children were tested on a task dealing with "conservation of number," requiring them to recognize that the rearrangement of a set of objects in space does not alter their number. Three different groups of the children were given three different varieties of training, each designed to provide them with a mediational way of arriving at conservation of number. A fourth group served as a control, and was given no training. The results were that no effects could be shown of any of the kinds of training. The group improved their performance somewhat, but the experimental groups gained no more than the control group. Other experiments by Smedslund (1961a, 1961b, 1961c, 1961d, 1961e) lead to much the same conclusion.

Another example is provided by a recent experiment reported by Roeper and Sigel (1966), this time concerned with the tasks of conservation of quantity, using standard situations described by Piaget and Inhelder (1964) for conservation of substance, liquid substance, weight, and volume. In this case the trained groups of 5-year-old children were given fairly extensive general training in classifying, in reversibility, in seriation, three mental operations identified by Piaget as involved in the development of ideas of conservation in children. To summarize individual results very briefly, it was found that some trained children *did* improve on some tasks, but not on all of them. In contrast, the untrained control children showed no improvement. But the effectiveness of training was by no means general—one child might achieve a success in conservation of weight, but not in conservation of volume.

There have been quite a number of experiments using conservation-type tasks, and I have only mentioned here what seem to me a couple of representative examples. Generally speaking, the results seem to be summarizable as follows. Tasks which require young children to respond to situations reflecting conservation of substance, volume, weight, and number do not appear to be readily modifiable by means of instruction and training which is aimed rather directly at overcoming the typical deficiencies exhibited by children. Where such training has been shown to have some effect, it is usually a very specific one, tied closely to the situation presented in training, and not highly generalizable. On the whole, any impartial review of these studies would doubtless be forced to conclude that they do not contradict Piaget's notions of cognitive adaptation, and in fact appear to lend some support to the importance of maturational factors in development.

It is my belief that there is an alternative theory of intellectual development to which many students of child behavior would subscribe. In particular, it is one that would be favored by those whose scientific interest centers upon the process of learning. Naturally enough, it is one that emphasizes learning as a major causal factor in development, rather than as a factor merely involved in adaptation. It is easy enough to identify the philosophical roots of such a theory in American psychology. Perhaps the proponents who most readily come to mind are John B. Watson (1924) and B. F. Skinner (1953), both of whom have given great weight to the importance of environmental forces of learning in the determination of development.

But philosophy is not enough. As Kessen (1965, p. 271) points out, for some reason not entirely clear, those theorists who have generally emphasized the influences of environment, as opposed to growth, have also generally espoused a rather radical type of associationism. Thus, they have maintained not only that learning is a primary determinant of intellectual development, but also that what is learned takes the form of simple "connections" or "associations." To account for how a child progresses from a stage in which he fails to equate the volume of a liquid poured from one container into a taller narrower container, to a stage in which he succeeds in judging these volumes equal, seems to me quite impossible to accomplish on the basis of learned "connections." At the least, it must be said that there is no model that really does this. Furthermore, the experiments, which have tried to bring about such a change, largely on the basis of "associationistic" kinds of training, have not succeeded in doing so.

In contrast to a weak and virtually empty "associationistic" model, it is not surprising that a theory like Piaget's has considerable appeal to students of development. It tells us that there are complex intellectual operations, which proceed generally from stages of motor interaction through progressive internal representation to symbolic thought. As an alternative, we may choose a theory like Bruner's (1965), which conceives the developmental sequence to be one in which the child represents the world first inactively (through direct motor action), then ikonically (through images), and finally symbolically. These are models with a great deal of substance to them, beside which the bare idea of acquiring "associations" appears highly inadequate to account for the observed complexities of behavior.

Cumulative Learning Model

The point of view I wish to describe here states that learning contributes to the intellectual development of the human being because it is *cumulative* in its effects. The child progresses from one point to the next in his development, not because he acquires one or a dozen new associations, but because he learns an ordered set of capabilities which build upon each other in progressive fashion through the processes of differentiation, recall, and transfer of learning. Investigators of learning know these three processes well in their simplest and purest forms, and spend much time studying them. But the cumulative effects that result from discrimination, retention, and transfer over a period of time within the nervous system of a given individual have not been much studied. Accordingly, if there is a theory of *cumulative learning*, it is rudimentary at present.

If one cannot, as I believe, put together a model or cumulative learning whose elements are associations, what will these entities be? What is it that is learned, in such a way that it can function as a building block in cumulative learning? Elsewhere (Gagné, 1965) I have outlined what I believe to be the answer to this question, by defining a set of learned capabilities which are distinguishable from each other, first, as classes of human performance, and second, by their requirements of different conditions for their acquisition. These are summarized in Figure 1.1.

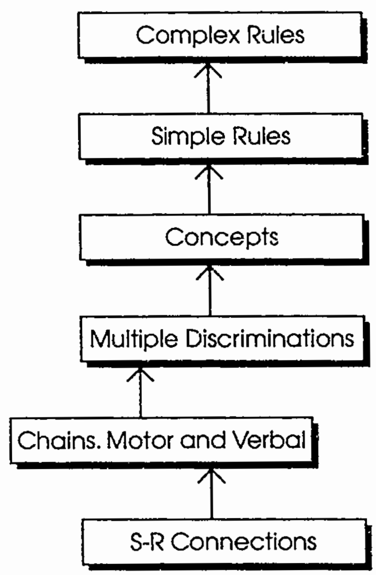

Figure 1.1 A General Sequence for Cumulative Learning.

The basic notion is that much of what is learned by adults and by children takes the form of complex rules. An example of such a rule is, "Stimulation of a neural fiber changes the electrical potential of the outer surface of the neural membrane relative to its inner surface." I need to emphasize that "rule" refers to what might be called the "meaning" of such a statement, and not to its verbal utterance. These ideas are learned by individuals who have already learned, and can recall, certain simpler rules; in this instance, for example, one of these simpler rules would be a definition of electrical potential. Simple rules, in their turn, are learned when other capabilities, usually called concepts, have been previously learned. Again, in this instance, one can identify the presence of concepts like "stimulation," "fiber," "electric," "surface," and "membrane," among others. In their turn, the learning of concepts depends upon the availability of certain discriminations; for example, the idea of surface has been based in part on prior learning of discriminations of extent, direction, and texture of a variety of actual objects. In the human being, multiple discriminations usually require prior learning of chains, particularly those which include verbal mediators. And finally, these chains are put together from even simpler learned capabilities which have traditionally been called "associations" or "Stimulus-Response (S-R) connections."

The identification of what is learned, therefore, results in the notion that all these kinds of capabilities are learned, and that each of them is acquired under somewhat different external conditions. By hypothesis, each of them is also learned under different *internal* conditions; the most important of these being what the individual already has available in his memory. It is clear that associations, although they occupy a very basic position in this scheme, are not learned very frequently by adults, or even by 10-year-olds. Mainly, this is because they have already been learned a long time ago. In contrast, what the 10-year-old learns with great frequency are rules and concepts. The crucial theoretical statement is that the learning of such things as rules and concepts depends upon the recallability of previously learned discriminations, chains, and connections.

Examples of Cumulative Learning

Some verification of the idea of cumulative learning has come from studies of mathematics learning, an example of which is Gagné, Mayor, Garstens, and Paradise (1962). Seventh-grade students acquired a progressively more complex set of rules in order to learn the ultimate performances of adding integers, and also of demonstrating in a logical fashion how the addition of integers could be derived from number properties. The results of this study showed that with few exceptions, learners who were able to learn the capabilities higher in the hierarchy also knew how to do the tasks that were reflected by the simpler rules that were lower in the hierarchy. Those who had not learned to accomplish a lower-level task generally could not acquire a higher level capability to which it was related.

These results illustrate the effects of cumulative learning. They do so, however, in a very restricted manner, since they deal with a development period of only two weeks. Another form of restriction arises from the fact that only rules were being learned in this study, rather than all of the varieties of learned capabilities, such as concepts, discriminations, chains, and connections. In another place (Gagné, 1965, p. 181) I have attempted to spell out in an approximate manner a more complete developmental sequence, applicable to a younger age, pertaining to the final task of ordering numbers. In this case it is proposed that rules pertaining to the forming of number sets depend upon concepts such as joining, adding, and separation. These rules in turn are dependent upon simpler capabilities like multiple discriminations in distinguishing numerals; and these depend upon such verbal chains as naming numerals and giving their sequence. Following this developmental sequence to even earlier kinds of learning, it is recognized that children learn to draw the numerals themselves, and that at an even earlier stage they learn the simplest kinds of connections such as orally saying the names of numerals and marking with a pencil.

It should be quite clear that this cumulative learning sequence is only a suggested, possible one, and not one that has received verification, as was true of the previous example. I doubt that it is at all complete. It attempts to show that it is possible to conceive that all of the various forms of learned capabilities are involved in a cumulative sense in the first-grade task of ordering numbers. Not only are specific rules directly connected with the task, but also a particular set of concepts, discriminations, chains, and connections which have been previously learned. Normally, such prior learning has taken place over a period of several years, of course. And this means that it would be quite difficult to establish and verify a cumulative learning sequence of this sort in its totality. If such verification is to be obtained, it must be done portion by portion.

A Cumulative Learning Sequence in Conservation

Can a cumulative learning sequence be described for a task like the conservation of liquid, as studied by Piaget (cf. Piaget & Inhelder, 1964)? Suppose we consider as a task the matching of volumes of liquids in rectangular containers like those shown in Figure 1.2. When the liquid in A is poured into Container B, many children (at some particular age levels) say that the taller Container B has more liquid. Similarly, in the second line of the

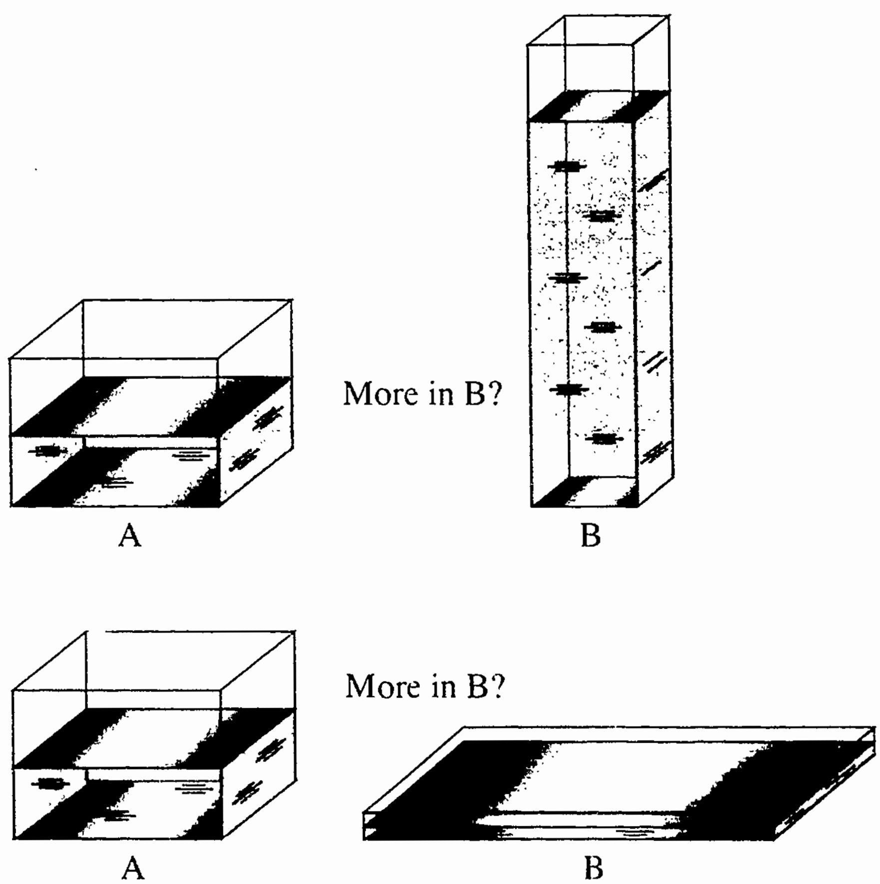

Figure 1.2 Two Tasks of "Conservation of Liquid" of the Sort Used by Piaget and Other Investigators.

figure, children of particular ages have been found to say that the volume in the shallower Container B, exhibiting a larger surface area, is the greater.

What is it these children need to have learned, in order to respond correctly to such situations as these? From the standpoint of the cumulative learning model, they need to have learned many things, as illustrated in Figure 1.3.

First of all, you may want to note that "conservation of liquid" is not a behaviorally defined task; accordingly I have attempted to state one that is, namely, "judging equalities and inequalities of volumes of liquids in rectangular containers." However, such behavior is considered to be rule-based, and could be restated in that form.

"Nonmetric" is also a word requiring comment. What this diagram attempts to describe is a cumulative learning sequence (in other words, a developmental sequence), that obtains approximate volume matchings without the use of numbers, multiplication, or a quantitative rule. I believe such a learning sequence can occur, and perhaps sometimes does occur, in children uninstructed in mathematical concepts of volume. Choosing this particular sequence, then, has the advantage of application to children who are more like those on whom Piaget and others have tried the task. But let it be clear that it is by no means the *only* learning route to the performance of this task. There must be at least several such sequences, and obviously, one of them is that which *does* approach the final performance through the multiplication of measured quantities.

The first subordinate learning that the child needs to have learned is the rule that length, width, and height determine the volume of a liquid (in rectangular containers). A change in any of these will change volume. This means that the child knows that any perceived change in any of these dimensions means a different volume. Going down one step in the learning required, we find three rules about compensatory changes in two dimensions when another dimension remains constant. That is, if the height

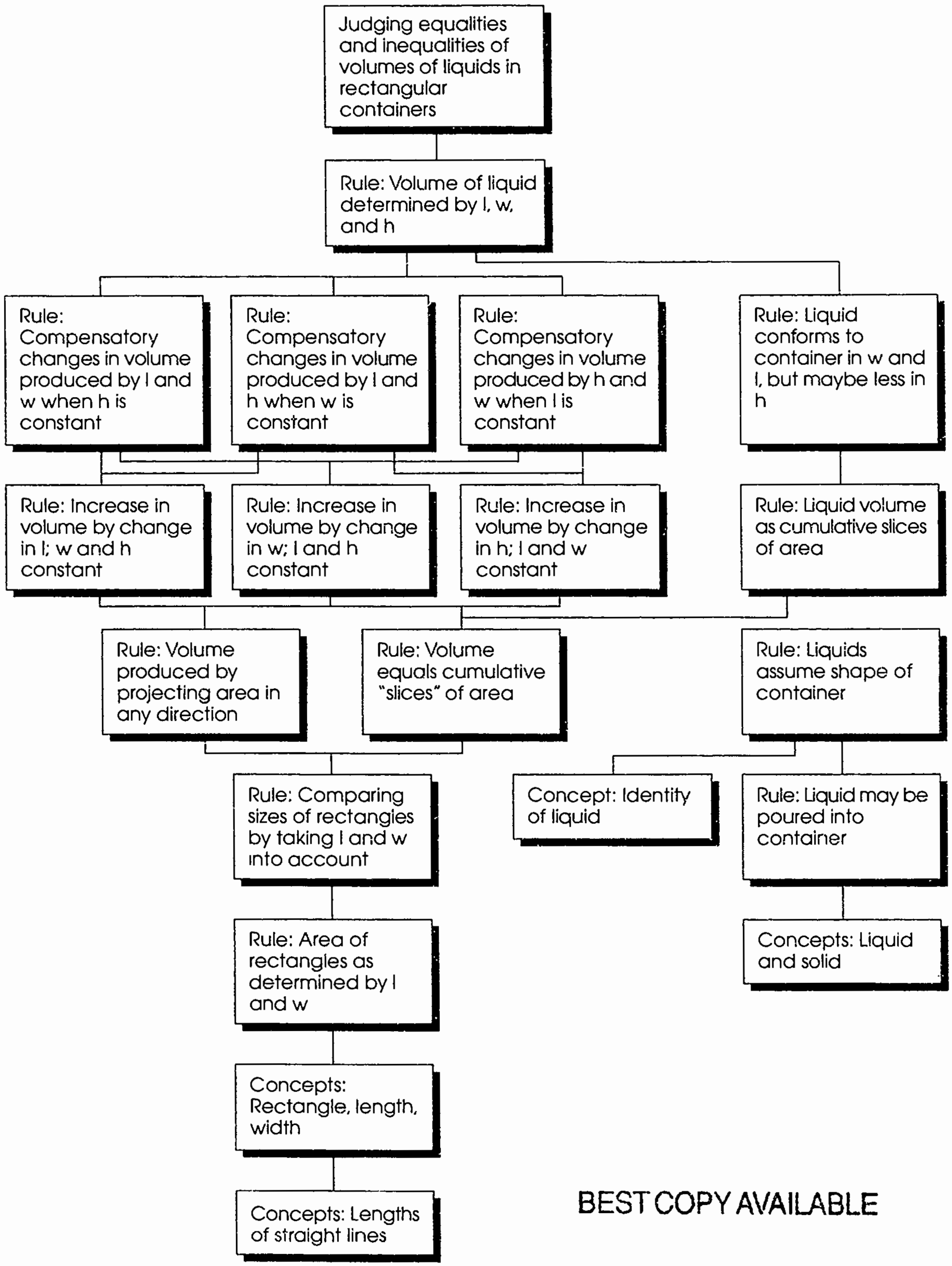

Figure 1.3 A Cumulative Learning Sequence Pertaining to the Development of Nonmetric Judgments of Liquid Volume.

of a liquid remains the same in two different containers one can have the same volume if a change in width is compensated by a change in length. This is also similar for the other instances of compensatory change.

Now, in order for a child to learn these compensatory rules, the model says, he must have previously learned three other rules, relating to change in only one dimension at a time. For example, if length is increased while width and height remains constant, volume increases. Again, similarly for the other single dimensions. These rules in turn presuppose the learning of still other rules. One is that volume of a container is produced by accumulating "slices" of the same shape and area; and a second is that volume can be projected from area in any direction, particularly, up, to the front or back, and to the right or left. Finally, one can work down to considerably simpler rules, such as those of comparing areas of rectangles by compensatory action of length and width; and the dependence of area upon the dimensions of length and width. If one traces the development sequence still farther, he comes to the even simpler learned entities, concepts, including rectangle, length, width, and an even simpler one, the concept of length of a straight line.

Just to complete the picture, the model includes another branch which has to do with liquids in containers, rather than with the containers themselves, and which deals on simpler levels with rules about liquids and the concept of a liquid itself. This branch is necessary because at the level of more complex rules, the child must distinguish between the volume of the liquid and the volume of the container. Of particular interest also is the concept of liquid identity, the recognition by the child that a given liquid poured into another container is still the same liquid. Such a concept may fairly be called a "logical" one, as Piaget does. Bruner (1966) presents evidence tending to show that identity of this primitive sort occurs very early in the child's development, although its communication through verbal questions and answers may be subject to ambiguities.

Having traced through the "stages" in learning, which the model depicts, let me summarize its characteristics as a whole, and some of their implications.

1. First, it should be pointed out that this model, or any other derived in this manner, represents the hypothesis-forming part of a scientific effort, not the verification part. This specific model has not been verified, although it would seem possible to do so. In the process of verification, it is entirely possible that some gaps would be discovered, and this would not be upsetting to the general notion of cumulative learning.
2. According to this way of looking at development, a child has to learn a number of subordinate capabilities before he will be able to learn to judge equalities of volume in rectangular containers. Investigators who have tried to train this final task have often approached the job by teaching one or two, or perhaps a few, of these subordinate capabilities, but not all of them in a sequential manner. Alternatively, they may have given direct practice on the final task. According to the model, the incompleteness of the learning programs employed accounts for the lack of success in having children achieve the final task.
3. In contrast to other developmental models, some of them seemingly based on Piaget's, the cumulative learning model proposes that what is lacking in children who cannot match liquid volumes is not simply logical processes such as "conservation," "reversibility," or "seriation," but concrete knowledge of containers, volumes, areas, lengths, widths, heights, and liquids.

Generalization and Transfer

There is still another important characteristic of a cumulative learning model remaining to be dealt with. This is the fact that any learned capability, at any stage of a learning sequence, may operate to mediate other learning that was not deliberately taught. Generalization or transfer to new tasks, and even to quite unanticipated ones, is an inevitable bonus of learning. Thus the child who has been specifically instructed via the learning sequence shown in the previous figure has actually acquired a much greater learning potential than is represented by the depicted sequence itself.

Suppose, for example, we were to try to get a child who had already learned this sequence to learn another requiring the matching of volumes in cylindrical containers. Could he learn this second task immediately? Probably not, because he hasn't yet learned enough about cylinders, volumes of cylinders, and areas of circles. But if we look for useful knowledge that he *has* acquired, we find such things as the rule about liquids assuming the shapes of their containers, and the one about volumes being generated by cumulative "slices" of areas. The fact that these have been previously learned means that they do not have to be learned all over again with respect to cylinders, but simply recalled. Thus a cumulative learning sequence for volumes of liquids in cylinders could start at a higher "stage" or "level" than did the original learning sequence for rectangular containers. Cumulative learning thus assumes a built-in capacity for transfer. Transfer occurs because of the occurrence of specific identical (or highly similar) elements within developmental sequences. Of course, "elements" here means rules, concepts, or any of the other learned capabilities I have described.

It will be noted that the final tasks of the developmental sequences I have described are very specific. They are performances like "matching volumes in rectangular containers." Does the existence of transfer imply that if enough of these specific tasks are learned, the child will thereby attain a highly general principle that might be called substance conservation? The answer to this question is "no." The model implies that an additional hierarchy of higher-order principles would have to be acquired before the individual might be said to have a principle of *substance conservation.* Transferability among a collection of such specific principles will not, by itself, produce a capability, which could be called the principle of substance conservation, or the principle of conservation.

What *is* possible with a collection of specific principles regarding conservation, together with the transfer of learning they imply, is illustrated in Figure 1.4.

Suppose the learner, making use of transfer of learning where available, has acquired all four of the specific conservation principles shown in the bottom row—dealing with conservation of number, conservation of liquid volumes in both rectangular and cylindrical containers, and conservation of

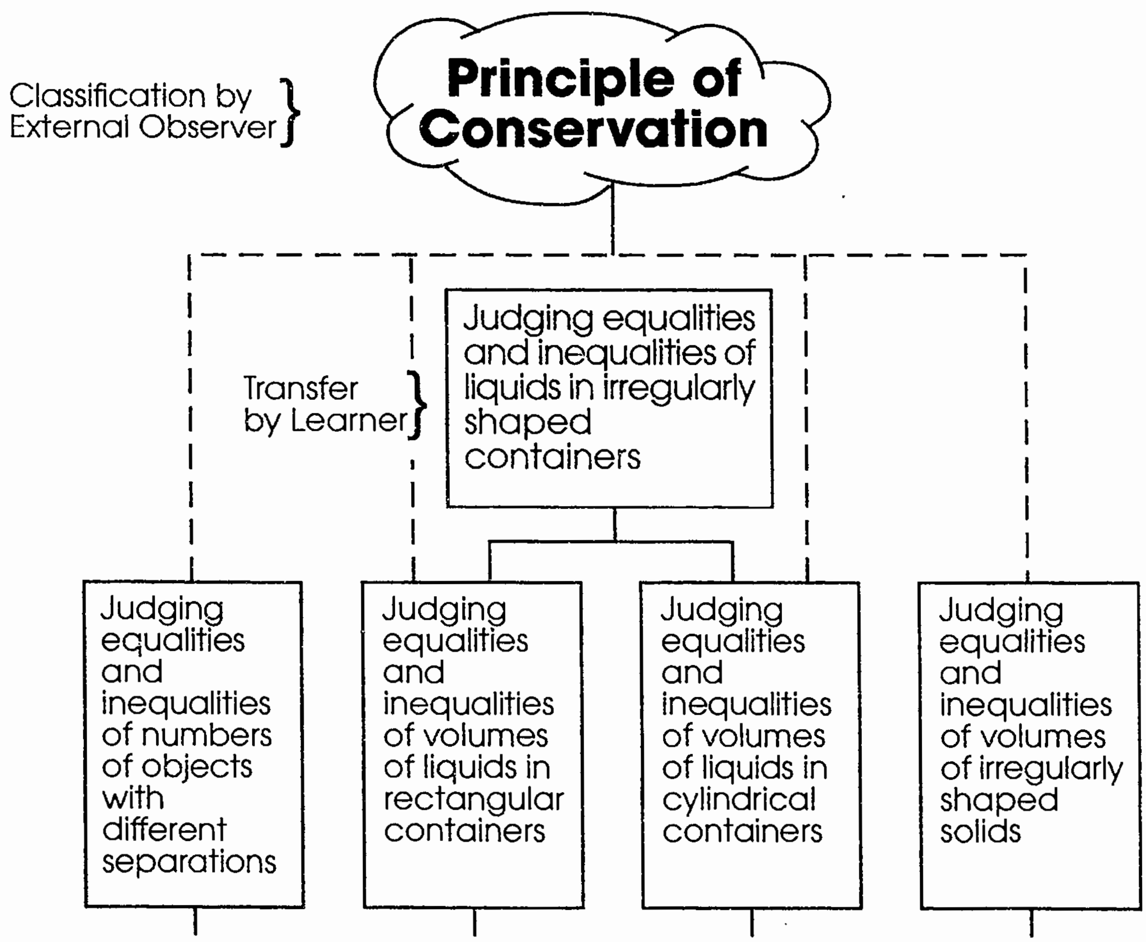

Figure 1.4 The Contrast Between a Principle Acquired by the Learner Through Transfer From Previously Learned Principles, and a "Principle of Conservation" Used as a Classificatory Aid by an External Observer.

solid volumes. Others could be added, such as conservation of weight, but these will do for present purposes. The property of learning transfer makes possible the ready acquisition of still more complex principles, such as the example given here—judging the volumes of liquids, in irregularly shaped containers. It is easy to see that by *combining* the principles applicable to volume of rectangular containers, and others applicable to cylindrical containers, a learner could easily acquire a capability of estimating volumes of irregularly shaped containers. Other kinds of combinations of previously acquired knowledge are surely possible. As I have pointed out, this is the kind of generalizing capability made possible by the existence of learning transfer.

In contrast to this new entity in the developmental sequence, an external observer may, if he wishes, look at the collection of what the individual has learned about conservation, and decide he will call this *collection* the principle of conservation. An external observer is perfectly capable of doing this, and he may have legitimate reasons for doing so. But what he achieves by so doing is still an abstraction which exists in his mind, and not in the mind of the learner. If the external observer assumes that because he can make this classification of such an entity as a principle of conservation, the same entity must therefore exist as a part of the learner's capabilities, he is very likely making a serious mistake. The learner has only the specific principles he has learned, along with their potentialities for transfer.

I believe that many of the principles mentioned by Piaget, including such things as reversibility, seriation, and the groupings of logical operations, are abstractions of this sort. They are useful descriptions of intellectual processes, and they are obviously in Piaget's mind. But they are not in the child's mind.

Another example of how such abstractions may be useful for planning instructional sequences, but not as integral components of intellectual development, may be seen in exercises in science for elementary school children, titled *Science—A Process Approach*, developed by the Commission on Science Education of the American Association for the Advancement of Science (1965). One of the processes these exercises intend that young school children learn is called observation. But it would be incorrect to think that the designers of this material believe that something like the Principle of Observation is to be directly taught to children as an intellectual entity. Observation in this case is an abstractraction, which exists in the minds of the designers, but not in the minds of children. What the children do learn is a rather comprehensive collection of specific capabilities, which enable them to identify several fundamental properties of the world of objects—tastes, odors, sounds, the solid-liquid distinction, color, size, shape, texture, as well as changes in these. Each is a fairly specific capability, applying to a class of properties only one step removed in abstraction from the objects themselves. At the same time, transfer of learning makes it possible for the child to build upon these things he has learned, and to learn to identify objects or changes in them in a manner which requires the use of several senses at once.

These instructional materials make it clear that the specific capabilities of observation are considered to have transfer value to other kinds of things which are learned later on—to classifying and measuring and predicting and inferring, as well as to other activities involved in scientific experimentation. Transfer of these specific capabilities takes place in many ways and in many directions. But the processes themselves are not acquired as a part of the child's mental constitution. They are merely external names for a collection of capabilities, as well as for the developmental sequences on which these are built.

Returning to the general theme, it should be clear that the various kinds of capabilities that children learn cumulatively, despite their relative specificity, provide a totality of transferable knowledge that is rich in potentialities for further learning. New combinations are possible at any time between principles acquired, let us say, in a context of containers of water, on the one hand, and in the very different context of exchanges of money, on the other. Furthermore, it is recognized that such generalizations can readily occur when the individual himself initiates the intellectual activity; the new learning does not have to be guided by external instruction. The process of cumulative learning can involve and be contributed to by the operations of inductive and deductive thinking. The cumulative learning model obviously does not provide a theory of thinking; but it suggests the elements with which such a theory might deal.

Summary

What I have attempted to describe is a model of human intellectual development based upon the notion of cumulative learning, which contrasts in a number of respects with developmental theories whose central theme is maturational readiness, as well as with those (of which the best known is Piaget's) of cognitive adaptation. This model proposes that new learning depends primarily upon the combining of previously acquired and recalled learned entities, as well as upon their potentialities for transfer of learning.

As for the entities which are learned, the model assumes that complex principles are formed from combinations of simpler principles, which are formed by combining concepts, which require prior learning of discriminations, and which in turn are acquired on the basis of previously learned chains and connections. The "stage" in which any individual learner finds himself with respect to the learning of any given new capability can be specified by describing (a) the relevant capabilities he now has; and (b) any of a number of hierarchies of capabilities he must acquire in order to make possible the ultimate combination of subordinate entities which will achieve the to-be-learned task. In an oversimplified way, it may be said that the stage of intellectual development depends upon what the learner knows already and how much he has yet to learn in order to achieve some particular goal. Stages of development are not related to age, except in the sense that learning takes time. They are not related to logical structures, except in the sense that the combining of prior capabilities into new ones carries its own inherent logic.

The entities that are acquired in a cumulative learning sequence are relatively specific. They are specific enough so that one must specify them by naming the class of properties of external objects or events to which they will apply. At the same time, they possess great potential for generalization, through combination with other learned entities by means of a little understood, but nevertheless dependable, mechanism of learning transfer.

This kind of generalization through learning transfer is internal to the learner, and thus constitutes a genuine and measurable aspect of the learner's intellectual capability. Another kind of generalization is not necessarily a part of the learner. This is the classification an external observer may make of a collection of learned capabilities. While the observer naturally has the capability of making such a generalization (and often does so), the learner may not have such a capability. Thus, an external observer may classify a collection of learner capabilities as "the conservation principle," or "the principle of reversibility." Such abstractions have a number of uses in describing intellectual capabilities. Because they are so described, however, does not mean that the learner possesses them, in the same sense that the external observer does.

Intellectual development may be conceived as the building of increasingly complex and interacting structures of learned capabilities. The entities, which are learned, build upon each other in a cumulative fashion, and transfer of learning occurs among them. The structures of capability so developed can interact with each other in patterns of great complexity, and thus generate an ever-increasing intellectual competence. Each structure may also build upon itself through self-initiated thinking activity. There is no magic key to this structure—it is simply developed piece by piece. The magic is in learning and memory and transfer.

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Chapter 2

Learning Hierarchies[3]

Robert M. Gagné

This article builds upon the theory of cumulative learning that was described in the previous chapter. It blends theoretical explanations with the description of a practical analysis technique for designers to use when determining the appropriate content for a given piece of instruction. This work continues to reflect Gagné's interest in school curriculum applications. Learning hierarchies, originally called hierarchies of knowledge, were not new to Gagné in 1968; he had introduced them earlier in the 1960's in his studies of the acquisition of knowledge. His work in this area is interesting in that it reflects an early departure from the behavioral orientation that was predominant. However, it was consistent with the emphasis on behavioral objectives and the systematic analysis of instruction, both of which were then considered quite innovative.

[3] *Editor's Note:* From Gagné, R.M. (1968). Learning hierarchies. *Educational Psychologist, 6*, 1–9. This article was originally presented by Gagné at the Annual Meeting of the American Psychological Association, San Francisco, California, August 31, 1968. It was the presidential address that he presented as retiring president of Division 15 of the Association.

A few years ago, in the course of studies of the learning of tasks resembling those learned in schools (Gagné, 1962), I used the term "learning hierarchy" to refer to a set of specified intellectual capabilities having, according to theoretical considerations, an ordered relationship to each other. It was possible, I stated, beginning with a clear statement of some terminal objective of instruction, to analyze this final capability into subordinate skills in an order such that lower-level ones could be predicted to generate positive transfer to higher-order ones. The entire set of ordered intellectual skills formed a hierarchy that was considered to bear some relation to a plan for effective instruction.

An example of a hierarchy, pertaining to the addition of integers, is shown in Figure 2.1. In the framework of instruction in "modern math," children learn two distinguishable terminal capabilities: one of these, shown on the right, is simply finding sums of positive and negative numbers; a second, shown on the left, constitutes a demonstration of the logical validity of adding any pair of integers, using the properties of the number system to effect this demonstration. For both these tasks, an analysis revealed a set of subordinate capabilities shown in the figure, some in common and some not in common, ranging down to some relatively simple skills which the children were presumed to possess at the beginning of their instruction.

What I should like to do at this point is to tell you some things I have learned about learning hierarchies in the last couple of years. In part, these things have been learned by my research and the research of other people; and in part, from the various reactions I have received about them from many sources. I need to say, surely, that critical comments have most certainly caused me to rethink and clarify, at least in my own mind, what the nature, characteristics, and uses of learning hierarchies may be. Since such hierarchies contain elements of theory, I am most eager to alter or augment these elements to provide improved prediction, if that is possible. What I am likely to be most obstinate about changing, however, is the basic idea or the feasibility of predicting optimal sequences of learning events.

Characteristics of Learning Hierarchies

What are the characteristics of a learning hierarchy? How does one know when he has one, and what precisely can be predicted from it? To find initial answers to such questions, one can review the kind of study which first gave rise to the idea. This was a study derived from an investigation of the learning of a task of constructing formulas for the sums of number

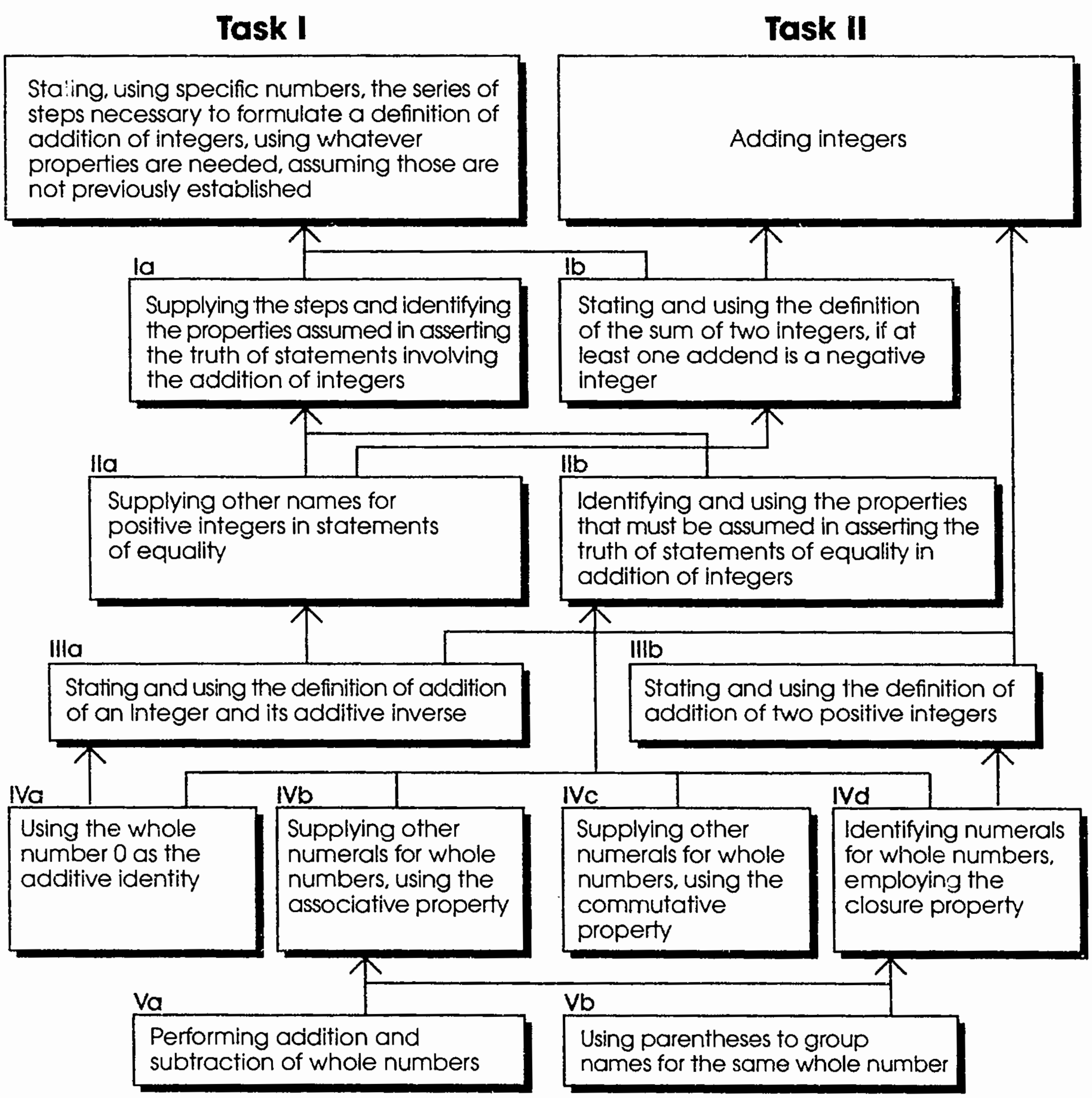

Figure 2.1 A Learning Hierarchy on the Addition of Integers (From Gagne, R.M., Mayor, J.R., Garstens, H.L. and Paradise, N.E. (1962). Factors in acquiring knowledge of a mathematical task. Psychological Monographs, 76, No. 526.).

series (Gagné, 1962). In the original study using programmed instruction (Gagné & Brown, 1961), individual differences in learning from the program were of course highly evident. One could have attributed them to differences in "intelligence," and let it go at that. But it seemed to me these differences in learning performance were more likely attributable to certain identifiable skills which were not directly represented in the program itself, but which were needed along the way in doing what the program demanded. They were activities that the learners could or could not do, and which the program was accordingly more or less successful in teaching them to do.

The next step was to figure out what these "subordinate skills" might be. Beginning with the final task, I found it was possible to identify nine subordinate capabilities, related to each other in an ordered way, by successively asking the question concerning each task, "What would the individual already have to know how to do in order to learn this new capability simply by being given verbal instructions?" It is probably of some importance to note that the kinds of capabilities identified in this manner did not directly pertain to number series, but rather included such skills as the following:

a) Identifying the location of numerals in a tabular array by means of letters giving their row and column location
b) Completing statements of equality by supplying missing numbers in equations containing mixed arithmetic operations
c) Identifying the numbers or letters in a tabular array which formed certain spatial patterns represented by lines connecting at 90 degrees and 45 degrees.

I emphasize that the subordinate skills so identified are not related to number series in a logical sense; what they are related to, psychologically, is the kind of behavior the learner has to engage in if the learner is going to be successful at figuring out from a tabular array of number series properties, how to formulate an equation for their sum.

Having identified a hierarchy of capabilities in this way, the next step was to test its validity. First, a test was made on a number of subjects to determine which of these subordinate tasks they already knew how to do. Two subjects could do all of the subordinate tasks but not the final one; two could do all but two; one all but three; and two all but four. Each of these learners was then taught to do whichever subordinate tasks he couldn't initially perform. Then, having completed this learning, each was given verbal directions about how to do the final task, without any practice on it. Six out of these seven subjects then proceeded to execute the final task of making a formula for four number series, which he hadn't seen before. Additional evidence showed that a similarly marked change in capability was brought about in these learners at each "level" of the hierarchy for which instruction had been given.

Certain patterns of responding to the tests of subordinate tasks also were revealed in this study. Specifically, those who got subordinate skill number 1 correct, also got all the skills lower in the hierarchy correct. Those who got number 2 correct, and missed number 1, got all the skills lower than number 2 correct also. In other words, in these seven learners, there was in fact an ordered relationship (similar to that displayed in a Guttman-type scale)[4] among the subordinate capabilities measured.

On the basis of this brief review, I should like to consider the question of what a learning hierarchy is. What properties of the learning hierarchy were either postulated or revealed in this study?

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[4] *Editor's Note:* Louis Guttman had an interest in the development of unidimensional scales—consisting of items unrelated to the characteristic being measured. He developed a technique called scale analysis, a major contribution to the methodology of questionnaire construction and analysis. A Guttman-type scale would be unidimensional in nature. For further information, see Guttman, L. (1944). A basis for scaling quantitative data. *American Sociological Review, 9,* 139–150.

First, the question by means of which the analysis is begun, namely, "What would the individual have to know how to do...etc.," implies that one is searching for subordinate tasks which will transfer positively to the learning of the task in question. The criterion for such transfer is a stringent one—it is desired that the subordinate skill or skills facilitate the learning to such an extent that it will occur when only verbal instructions, and no further trials of practice, are given. It is evident that choices are being made here, since there are perhaps a number of kinds of subordinate skills which would, under suitable conditions, exhibit some degree of transfer to a given learning task. The method doesn't imply that all of these are searched for, but only those that will meet this stringent criterion. Therefore, it is fair to say that a subordinate capability identified by this method is a skill which is hypothesized to exhibit a substantial amount of positive transfer to the learning of the skill in question.

Second, how does one know if the order assigned to the skills in the hierarchy is correct? To specify this order, one depends first of all on the application of knowledge about transfer of learning, which comes from a great number of sources. A general guide to such ordering is the one I have described (Gagné, 1965), in which simple responses are subordinate to chains or multiple discriminations, which in turn are subordinate to classifying, which in turn is subordinate to using principles or rules. But this of course is rather general guidance, and does not begin to account adequately for the specific choices that must be made in any particular instance. Sometimes one is not sure about the location of a subordinate capability, particularly as to whether it is truly subordinate or merely at the same level.

Empirical tryout of the series of hypotheses represented by a hierarchy seems to be a reasonable approach to this problem. On the basis of such a tryout, one can in effect determine whether a particular skill transfers positively to another, or whether they are independent, or whether perhaps they co-vary in their transfer effects. In one paper I have made some suggestions about how these determinations might be made (Gagné, 1967), but I perceive these to be very unsophisticated compared with procedures I can only dimly imagine. An example of a successful tryout of this sort is in a study by Cox and Graham (1966), using a task of elementary mathematics. They were able to show that an initially hypothesized order was incorrect, according to their results. When the hierarchy was rearranged, the existence of an order of subordinate skills was confirmed. Thus it seems to me reasonable to suppose that many individual hypotheses about transfer represented in a hierarchy may have to be checked by some empirical means. If they turn out to be wrong, the conservative conclusion surely is that something is wrong with the specific hierarchy proposed. To the contrary, however, it does not seem reasonable to conclude on the basis of such evidence that *all* hierarchies are wrong.

A third characteristic of hierarchies seems to be of considerable interest. Do they represent a sole learning route to the learning of the final task, or perhaps even a most efficient learning route? Must each individual learner necessarily proceed to acquire each subordinate skill in order to enable him ultimately to learn the final task? By reference again to the method of analysis by means of which the hierarchy is generated, it is quite apparent that the answer to this question is no. Nothing in the method of analysis tells us about the capabilities of the individual learner. A given individual may be able to "skip" one or more of the subordinate tasks, just as a given learner may be able to "skip" parts of an adaptive program of instruction. Another individual may be able to bring to bear on the learning of any given skills some capability which comes from quite a different domain of knowledge, which is not even represented in the hierarchy.

A learning hierarchy, then, in the present state of our knowledge, cannot represent a unique or most efficient route for any given learner. Instead, what it represents is the most probable expectation of greatest positive transfer for an entire sample of learners concerning whom we know nothing more than what specifically relevant skills they start with.

A related point needs to be made about what a learning hierarchy represents, and what it does not represent. Perhaps the best way to say this is that a learning hierarchy does not represent everything that can be learned, nor even everything that is learned, within the domain it attempts to describe. In particular, a diagram of a hierarchy does not represent what is perhaps the most important result of learning, the potentiality for transfer that is generated. I have spoken of the events reflected in a learning hierarchy as *cumulative learning* (Gagné, 1968). The cumulative effects of such learning show themselves, in a minimal fashion, by the occurrence of positive transfer from one level of skill to another. But beyond this, each new capability that is learned may generalize to many other situations and domains that cannot possibly be represented on a single chart. Consider, for example, how a child who has learned the skill of volume conservation in rectangular containers, and the skill of conservation in cylindrical containers, may then learn to "conserve" volume in irregularly shaped containers (Gagné, 1968, p. 187). I have pointed out a number of particular subordinate skills from which positive transfer may be expected. The new task can be learned much more quickly than the old, not because the latter is subordinate to it, but because there are many common subordinate skills from which positive transfer may be expected.

According to this reasoning, there are latent consequences of cumulative learning, which are not directly represented on a diagram of a learning hierarchy. Were they to be represented, one would have to draw lines of transfer, somewhat as indicated in Figure 2.2. Depending on particular circumstances in the individual learner, there may be transfer from a lower level, in other words, "skipping." As another possibility, transfer may occur from quite a different domain of knowledge, as when one uses a skill at identifying number series patterns to solve a problem in classifying patterns of letters. Still a third possibility, which should not be overlooked, is the atypical combination of subordinate skills which, while they may seem conceptually very different, may in the case of an individual learner be able to combine to yield a rather unexpected source of learning transfer. A learning hierarchy cannot, in any practical sense, represent all of these possibilities. Yet to deny their existence would be wrong, and in fact quite contrary to the basic conception of what cumulative learning is supposed to accomplish.

Intellectual Skills

I turn now to one of the most important characteristics of learning hierarchies, and one concerning which I myself have been inconsistent in past writings. The question is, what exactly are these entities, sometimes called capabilities, which make up a learning hierarchy? The answer I would now give is the following. They are *intellectual skills*, which some writers would perhaps call *cognitive strategies*. What they are not is just as important. They are not entities of verbalizable knowledge. I have found that when deriving them, one must carefully record statements of "what the individual can do," and just as carefully avoid statements about "what the individual knows."

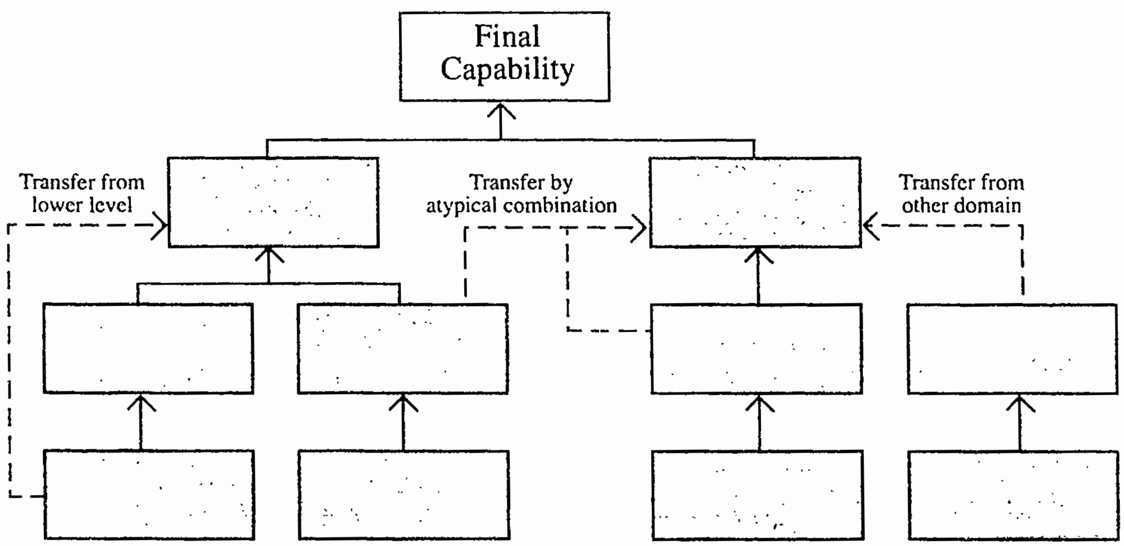

Figure 2.2 The Latent Consequences of Cumulative Learning, Indicated by Sources of Positive Transfer to the Learning of Advanced Capabilities.

I believe that my previous formulation of these entities is misleading, when it deals with what are called "concepts" and "principles." I should prefer to substitute for these, words emphasizing capabilities for action, such as "classifying," and "rule-following." This is more than a nominal change, however. I mean that what learning hierarchies describe is, in computer language, subroutines of a program; what they do not describe is the facts or propositions retrievable from memory as verbalizable statements.

Why do I emphasize this distinction, and what has led me to make it? First, it is surely noteworthy that the original hierarchies were developed in connection with mathematics tasks. If one stops to think about it, the substance of mathematics is largely a set of skills for manipulating numbers. They differ in complexity, of course, and also in specificity. But they are always intellectual skills, and they are not (and probably should not be) verbalizable knowledge. In the original study using number series (Gagné, 1962), for example, what was being learned was not "knowledge" about number series, but a set of particular *skills* of forming relationships among sets of numbers displayed in a systematic array.

You may recall that I incautiously attempted to generalize the ideas of learning hierarchies to such subject matter fields as the social sciences (cf. Gagné, 1967). In doing this, it is quite easy to fall into the trap of describing "knowledge" entities rather than skill entities. For example, some time ago one of my students worked out a learning hierarchy on weather prediction, with my help and acquiescence. The idea was to teach fourth graders how to predict weather from a weather chart superimposed on a map showing terrain features. The subordinate entities of this hierarchy had a high degree of plausibility, and appeared to describe what the child needed to know if he was going to predict the weather. When a teaching program based upon this chart was tried out, with much good will and persistence, the results can most succinctly be described by saying that it didn't work. The children did not learn much when a sequence of instruction based upon this chart was followed. Under these circumstances, little or no evidence could be seen in the data that positive transfer was occurring from one level of the hierarchy to the next.

I believe that the fundamental reason for this lack of success was that this was not a learning hierarchy for the task of predicting weather. It did not represent the intellectual skills the child needs to possess in tackling the job of figuring out from the "weather chart" how to make a forecast of the weather. I haven't yet made an analysis that satisfies me, but I suspect the intellectual skills that should be included are such things as these: (1) from general descriptions, formulating relevant propositions in syllogistic form; (2) making a systematic review of the effects of specific factors on an air mass; and (3) constructing specific statements describing weather at designated future times. It should be noted that such skills as these were not represented in the original formulation. They represent intellectual operations that the child can *do*. But they are not descriptions of what he *knows* (that is, of what he can recall in the sense of non-verbatim verbal propositions).

Then there is the evidence about the effectiveness of certain kinds of sequences in instruction, or in instructional programs. First I should say that I am not sure a learning hierarchy is supposed to represent a *presentation sequence* for instruction in an entirely uncomplicated way. Presumably, there should be some relation between an ordered set of intellectual skills and an ordering of a sequence of presentation of a set of frames or topics in an instructional program. Results like those of Payne, Krathwohl, and Gordon (1967), however, surely serve to give added emphasis to the distinction between verbalizable knowledge and intellectual skills. The painstaking study conducted by these investigators showed in a most convincing way that sequence of presentation, so far as reasonably mature adult learners are concerned, does not affect what is learned. The authors of this study suggest that, even when frames or topics are presented in scrambled order, the adult learner is able to make them into a coherent and meaningful internal arrangement, and to learn from them. Accordingly, one is led to believe from this study, or others like it, that a learner may acquire certain intellectual skills from a presentation that is quite disorganized when viewed as a sequence of verbalizable knowledge.

It is conceivable that this line of reasoning also applies to the study of Merrill (1965), who found no advantage to review and correction following each topic of an instructional program on imaginary science, as opposed to a condition of no review and correction. While I am by no means highly confident of this interpretation, I believe it might be examined within this general context. To summarize the point, it is that learners can acquire verbalizable knowledge, and even intellectual skills, from sequences of presentation that are altered in various ways from what may he considered "highly organized." The hypothesis I should like to reaffirm, however, is that regardless of presentation sequence, if one is able to identify the intellectual skills that are learned, he will find them to generate positive transfer in an ordered fashion.

Another line of thinking which I believe reinforces the distinction between intellectual skills and verbalizable knowledge comes from an analysis of the kinds of tasks described by Guilford (1967). While I have not undertaken an analysis of all the tasks Guilford describes, I have done some of them, and enough to lead me to believe that in most cases they are sampling both these kinds of entities. The performance being measured, in other words, typically samples the stored verbalizable knowledge the individual has available; and it also samples the intellectual skills that can be brought to bear upon the task. Consider a rather simple example, shown in Figure 2.3. "Which of these letter combinations does not belong with the rest?" The answer is 3, because it contains two vowels.

What kinds of intellectual skills does the individual bring to bear on such a task? I have suggested what I think they might be, in the hierarchy of boxes in Figure 2.3. They include such things as (1) making hypotheses which are tried and discarded, without repetition; and (2) distinguishing various features of letter combinations, such as vowels and consonants, location of letters in the alphabet, symbol repetition, and so forth. But it is equally apparent, is it not, that the individual who can solve this task also brings to bear some stored verbal entities: he must know what the vowels are, what the consonants are, what the alphabet is, and what the letters are. Both intellectual skills and an elementary kind of verbalizable knowledge are required in performing the task. But my hypothesis is that they are learned in different ways. The skills have an ordered relation to each other such that subordinate ones contribute positive transfer to superordinate ones. But I do not suppose that the verbalizable entities necessarily have this relationship to each other. Stated in overly simple fashion, one does *not* have to learn consonants and vowels first in order to insure greatest transfer to learning the entire set of letters; and one does

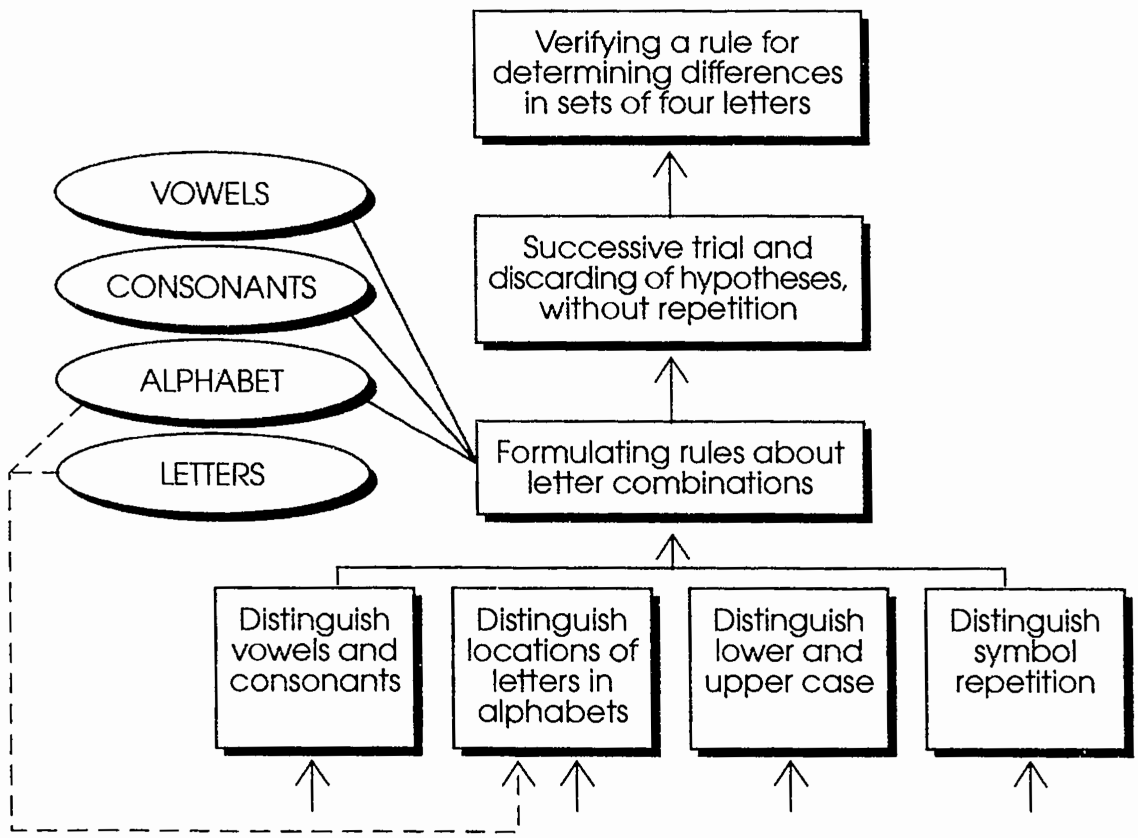

Figure 2.3 A Learning Hierarchy for a Task of Letter Combinations, indicating the contribution of Intellectual Skills (boxes) and Verbal Knowledge (circled entities). (Example is from Guildford, J.P. (1968). The Nature of Human Intelligence. New York: McGraw-Hill, p. 42).

not have to learn the letters first before learning their position in the alphabet.

This example is admittedly an elementary one, and I should not want that fact to obscure what I think to be the generalizability of this distinction. Consider another task, that of solving five-letter anagrams. The work of Mayzner and Tresselt (1965) and others has shown that such a task derives positive transfer from an identifiable set of intellectual skills, pertaining to the formulation of hypotheses regarding probabilities of letter combinations, probabilities of initial letter occurrences, and others. But it is equally evident that an individual learner who is successful at solving anagrams must have a store of verbalizable knowledge to call upon, which in this case are words. In solving a set of anagrams, the individual will show greater success if he knows a large number of words, besides having mastered the intellectual skills involved.

These are the major reasons, then, why I am led to think that learning hierarchies are descriptions of the relationships of positive transfer among intellectual skills, but that they are not descriptions of how one acquires verbalizable knowledge. Obviously, in solving any given problem, both kinds of retained entities must be brought to bear. And it seems equally true that, when a new intellectual skill is being acquired, knowledge must be available to the learner, since the skill cannot be learned "in a vacuum." I do not, in other words, wish to say that either kind of entity is the more important for learning. Both are essential. What seems to me most evident is that they need to be distinguished, and that the conditions governing positive transfer to them are probably very different.

To complete this account of the distinction between intellectual skills and verbalizable knowledge, it is of some importance to point out that this matter has possibly profound implications in its relation to the curriculum. Most educational psychologists, to be sure, recognize the distinction and clearly state that both intellectual skills and verbalizable knowledge must be learned in the schools. Ausubel (1968), for example, acknowledges the difference early in his text on educational psychology. Skinner (1968) draws a distinction between behaviors to be learned for dealing with particular classes of events, and precurrent self-management behaviors, which are more general in their applicability. Rothkopf (1968) distinguishes mathemagenic behaviors from the substance of what is learned. But the importance of each of these types of learned capability for curriculum design and planning would doubtless be estimated differently by these theorists, and probably still differently by me.

I should be inclined to entertain the notion that the most important things learned in school are intellectual skills, and not verbalizable knowledge. The major reason is, very simply, that one can always look up the knowledge, but the skills have to become "built-in." I can obviously not do justice to this very weighty question at this time. The curriculum implications are such as to lead to a heavy emphasis on what is often referred to as "process," in contrast to content. In elementary science, for example (cf. AAAS Commission on Science Education, 1967), this line of thinking leads one to prefer teaching children the intellectual skills involved in classifying, measuring, and predicting, rather than the verbalizable knowledge of the accomplishments of science.

Evidence Relevant to Learning Hierarchies

Now I must return to the major theme of learning hierarchies. To characterize them briefly, they represent an ordered set of intellectual skills, such that each entity generates a substantial amount of positive transfer to the learning of a not-previously-acquired higher-order capability. The learning of each entity also requires the recall of relevant verbalizable knowledge, which, however, is not itself represented in the hierarchy.

What kinds of evidence should be sought in the attempt to verify the hypotheses represented in a learning hierarchy, and what are the sources of such evidence? First of all, I should be inclined to seek evidence about the transfer of learning from one class of intellectual skill to another—in other words, from studies dealing with two successive levels of a hierarchy, rather than with all the levels at once. The reason for this is a fairly simple one involving consideration of the usual controls of an experiment. If one measures transfer from task A to task B, there will usually be certain proportions of success for task B. But one cannot then take the same groups of subjects, varying in their success with task B, and go on to measure transfer to task C, without violating certain principles of random selection. Thus, the basic experimental method remains one of measuring positive transfer from task A to task B; or alternatively, from task B to task C.

There is quite a good deal of evidence concerning positive transfer from one class of intellectual skill to another. For example, in the verbal paired-associate learning field, the evidence reviewed by Battig (1968) is to the effect that the learning of paired associates is typically facilitated by prior discrimination learning on stimulus-terms and response-terms, as well as by prior learning of stimulus coding responses. When one looks at categorizing skills (or concepts) like those exhibited by children in performing reversal-shift tasks, recent investigations such as those of Tighe (1965), Smiley and Weir (1966), and Johnson and White (1967) clearly demonstrate the importance of relevant prior learning of dimensional discriminations for transfer to the reversal task. Similarly, the different sort of classifying required in transposition tasks is shown to derive positive transfer from prior discrimination learning in the studies of Beaty and Weir (1966) and Caron (1966).

The importance of prior classification learning for positive transfer to rule learning is shown in a number of studies dealing with conservation tasks of a type derived from the work of Piaget. Beilin, Kagan and Rabinowitz (1966), for example, found prior classification training to transfer to the task of water-level representation in children, to a greater extent than verbal training. In this field of interest, a study of particular relevance to the present discussion is that of Kingsley and Hall (1967). These investigators made a specific analysis to derive a hierarchy of subordinate skills in conservation tasks. They then tested each child to determine which of the subordinate skills he knew, and proceeded to train each of the missing ones. The method, in other words, resembled that employed in "The acquisition of knowledge" (Gagné, 1962), and substantial amounts of positive transfer to the final conservation tasks were obtained.

There are also a number of recent studies verifying the general idea of positive transfer to problem-solving situations from prior learning on subordinate relevant rules. DiVesta and Walls (1967), for example, demonstrated positive transfer from relevant "pre-utilization" training to the Maier two-string problem. Davis (1967) showed the effectiveness for transfer of previously learned verbal rules to switch-light problems, and a similar theme is developed by Overing and Travers (1966, 1967) in their studies of the problem of hitting an underwater target. In problems concerning mathematical groups and combinatorial topology, Scandura and Wells (1967) demonstrated positive transfer effects from prior learning in concrete situations involving relevant rules.

In this brief sampling of relatively recent studies, one can see repeated many times the general affirmation of the hypothesis that the learning of each particular category of intellectual skill depends substantially, in a positive transfer sense, on the previous learning of another particular category of intellectual skill. In brief, problem-solving draws positive transfer from prior rule learning, which is contributed to in the same sense by prior classification learning, which is in turn strongly affected by prior discrimination learning, and so on. I should say, therefore, that I look for verification of the learning hierarchy idea in studies of positive transfer from one intellectual skill to another. In studies of this sort over the past few years, there is a good deal of confirming evidence.

The other major type of study from which evidence about learning hierarchies may be derived is one that attempts to try out a total hierarchy, applicable perhaps to a limited topic, but in which the various levels of intellectual skill are to be learned in a single instructional sequence. The collaborative studies I did on the learning of algebraic equation-solving and adding integers (Gagné & Paradise, 1961; Gagné, Mayor, Garstens, & Paradise, 1962), for example, are of this sort. The results one first obtains from such studies may indicate that some incorrect hypotheses were made concerning predictions about positive transfer. Specifically, a capability thought to be subordinate to another may turn out to be superordinate, or even coordinate. Such a finding calls for the rearrangement of the hierarchy, as was done, for example, in the previously mentioned study by Cox and Graham (1966) dealing with the addition of two-place numbers. Following such a step, the new hierarchy can then be tried out, in order to seek evidence of positive transfer from one "level" to the next.

I need to mention that methods of analyzing data from such a study are not at all clear. Various possibilities have been tried beginning with Guttman scaling techniques, but none seem entirely satisfactory as yet. It is highly encouraging to know, however, that the measurement techniques needed for such analyses are apparently being worked on by a number of highly competent people. Hopefully, these will contrast with the rather crude methods used in the study from which Figure 2.1 was taken. Just to remind you what these were, by reference to Figure 2.1, what we attempted to do was to find the probability of achieving Task 1 for those learners who had learned an immediately subordinate capability, Ia, and to contrast this probability with that for learners who had *not* learned the same subordinate capability. The findings were 73% for the first set of learners, and only 9% for the second set. In other words, there was indeed substantial positive transfer. Similar confirming findings were reported for all of the comparisons possible within the learning hierarchy.

My present estimate then is that there are two major kinds of study which are likely to provide evidence concerning learning hierarchies. One investigates only two "levels" of a hierarchy at a time, and in effect becomes a more-or-less traditional study of positive transfer between categories of intellectual skill. The other type attempts to construct a hierarchy which applies to longer sequences of instruction, and which after first establishing a suitable order for the capabilities to be learned, seeks a measure of the dependence (in the positive transfer sense) of one learned entity on another.

Concluding Statement

It will surely be apparent from this restatement and possible clarification of a theoretical view, that in one sense the notion of a learning hierarchy reduces itself to the notion of positive transfer. The question remains, what transfers to what? My answer has been, and still is, that the "what" of this question can be answered in terms of different varieties of learned capabilities. In particular, specific responses transfer to discriminations, which transfer to classifications, which transfer to rules, which in turn may transfer to more complex forms of rule-governed behavior, such as that exhibited in problem solving.

The entities that are affected by positive transfer in this manner deserve to be called intellectual skills or strategies. But it seems important to distinguish these from verbalizable knowledge. While the learning and retention of the latter entities must surely have a theoretical rationale, for example, Ausubel's (1968), it seems to me to differ in respect to the properties of positive transfer which are applicable to intellectual skills.

When one says, therefore, as I am inclined to say, that we need more evidence about learning hierarchies, he may simply be repeating something that has surely been said before: we need more evidence about positive transfer. Despite the encouraging signs from recent studies I have mentioned, it appears that there is an enormous amount still to be known about this subject. Perhaps reducing "learning hierarchies" to such familiar terms will encourage more investigation and more systematic thinking about this phenomenon, which is so obviously of central importance to education.

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Chapter 3

Domains of Learning[5]

Robert M. Gagné

A major contribution of Gagné has been his views regarding the varying categories of learning outcomes and their relevance for instruction. He calls these categories the domains of learning and has identified different principles for designing instruction for each domain. He refers to these principles as the conditions of learning. The domains and their related conditions served as the major thesis of his important book, The Conditions of Learning. These ideas are summarized in this article published after the second edition of Conditions. By this time Gagné was at Florida State University. This article also expands upon the distinctions he had previously made between his views regarding the impact of past learning and those who attribute differences among learners to biological and developmental changes.

5 *Editor's Note:* From "Domains of Learning," by R.M. Gagné, 1972, *Interchange, 3*, 1–8. Copyright 1972 by the Ontario Institute for Studies in Education. Reprinted by permission of Kluwer Academic Publishers. The ideas were originally presented in a presidential address to the American Educational Research Association.

Those who profess to study and improve education through methods of research are inevitably concerned with the human activity of learning. It is, after all, the capacity of human beings to learn that makes it possible, and necessary, for a society to have a set of institutions devoted to education. Educational research may, of course, concern itself rather directly with human learning activity, as when one investigates methods of instruction, modes of communication, or procedures for reinforcing the learner's behavior. Or, such research may be related to the activity of learning in a somewhat less direct way, as when the focus of investigation is the institutions established to bring about learning. Wherever the investigation fits along this broad spectrum, there can be little doubt that it is in some manner ultimately to be related to the question of how human beings learn.

From a dictionary, one can identify two primary meanings for the word "learning." Definition one is "the process of acquiring modifications in existing knowledge, skills, habits, or action tendencies." The second definition is "knowledge or skill that is acquired by instruction or study."

It is easy enough to identify domains of learning in its second meaning. We do so all the time when we speak of divisions of the curriculum—knowledge about history, society, biology, literature; and skills of language and mathematics. Such domains have been identified in a variety of ways in different periods. The referent is the *content* of learning.

What about the first meaning—the *process* of learning? Are there also domains of learning processes that need to be distinguished, or is it always a single process, to be classified only in terms of its second meaning—the domains of knowledge and skill within which learning occurs? For many years, it would appear, those who conducted research on the learning process proceeded more or less on the assumption that they were searching for a common set of characteristics of the learning process, which would apply whether the learner was engaged in learning to lace a shoe, to define a new word, or to write an essay. Nevertheless, in the course of time, it has evidently become increasingly difficult to deal with the varieties of learning that occur in schools without classifying them in some manner. Accordingly, a number of terms have been invented to differentiate classes of learning, in order to make it possible to think about the learning process more clearly. Such phrases as "cognitive learning," "rote learning," "discovery learning," "concrete vs. symbolic learning," "effective learning," "conceptual learning," and many others, are examples of this strong and demanding tendency.

Each of these categories has some usefulness, of course. However, it also appears that their usefulness is limited—they are not as generally useful as they ought to be. One can readily find examples, for instance, in which learning may be called rote in one situation, conceptual or cognitive in another. Many human performances that may be described as motor from one point of view turn out to be highly symbolic in some other sense. The domains that have been identified for the process of learning are limited in usefulness because they are not well differentiated either by means of the operations required to establish them, or by the consequences to which they lead.

The Need for Domains of the Learning Process

Why should the educational researcher be cognizant of domains of the process of learning? What need do they fulfill? What functions do they serve?

First, they are needed to distinguish the parts of a content area that are subject to different instructional treatments. The learning of science is not simply science learning, and the learning of language is not just language learning. Consider the learning of a foreign language as an example. One part of instruction must typically be concerned with the pronunciation of letters in words. The German word *Gemütlichkeit*, in order to be understood by a listener, must be said with the proper sound for the umlauted u, and for the letter combination *ch* and *ei* —sounds that the student whose native language is English is not used to making. In order to learn to make them, he needs a good deal of practice on these specific letter combinations, as they occur in various words. But what about another part of his foreign language learning, in which he must learn to respond to a German question with a German answer? Is the way to accomplish this to practice a set of German answers? Of course not, and no teacher of German would imagine that it is so. There are, then, different parts to this single subject that need to be *differentially* handled, so far as instruction is concerned. How shall one describe the different domains of the learning process that apply to the parts of this subject, as they do to the parts of other content areas?

A second need for distinctive domains of the learning process is that of relating the instructional procedures of one subject to those of another. If it is true that one cannot generalize about learning conditions from one part of a subject to another, is it nevertheless also true that similar parts can be found among different content areas? The existence of these comparable parts of different subjects is rather easy to demonstrate. Think of what a student is being asked to learn in mathematics, say, when one asks him to learn to answer the question, "What is a triangle?" We expect that he will be able to define this concept, perhaps by using his own words, but better still by showing how such a figure possesses characteristics of a closed curve and intersections of line segments. Suppose instead the subject is social science, and we want the student to answer the question, "What is a city?" In an entirely comparable way, we expect that he will be able to demonstrate a definition of this concept, by showing that a city possesses the characteristics of concentration of population, commerce, and transportation center. In both these subjects, very different in content, we are dealing with the *use of a definition*, and similar mental activities would be required in any other subject field. In other words, one of the kinds of things students are asked to learn is using definitions, and this is true whether we are dealing with mathematics, foreign language, science, or whatever.

A third reason for identifying domains of learning is that they require different techniques of assessment of learning outcomes. One cannot use a single way of measuring what has been learned. This is, of course, the basic point made by the pioneering work of Bloom (1956), Krathwohl, Bloom, and Masia (1964), and their associates. As this work amply demonstrates, one cannot expect to employ the same kind of test item, or question, to determine whether a student has learned an item of knowledge, on the one hand, or the ability to synthesize several different ideas, on the other hand. Again, different categories of the learning domain are needed for measurement, regardless of the particular subject matter. They are needed in order to avoid the serious error of assuming that if a student knows something about a topic, that he therefore is part of the way to knowing all he needs to know about that topic. Instead, he can learn many more things without ever accomplishing the latter goal; the reason is because he needs to undertake entirely different categories of learning, rather than more of the same. The ways used to measure these different categories are different, and it is these ways that demonstrate how distinct the mental processes are.

Learning Domains

There are, then, a number of reasons for trying to differentiate domains of the learning process that are orthogonal to content, but that at the same time are in opposition to the notion that all learning is the same. From the standpoint of an educational researcher, the search is for domains *within which generalizations of findings can be made.* If the researcher has obtained a result that shows certain conditions to be facilitative of learning, he needs to know how widely this result can be generalized. Does it apply across subject-matter, across age levels, across classrooms? It is this kind of research utilization question to which the differentiation of domains of learning may be most relevant.

I should like here to summarize my conclusions about the desirable distinctions of domains of learning, some of which I have briefly described elsewhere (Gagné, 1970a), before going on to discuss their implications for other kinds of distinctions applicable to the learning process. The domains I would distinguish are five, and I call them (1) motor skills, (2) verbal information, (3) intellectual skills, (4) cognitive strategies, and (5) attitudes.

1. *Motor skills* is a good category to begin with, because it is so generally recognized to be distinctive. These are the capabilities that mediate organized motor performances like tying shoelaces, printing letters, pronouncing letter sounds, using tools and instruments. As everyone knows, learning motor skills takes *practice*, in the sense of repetition of the essential motor act. This requirement, in fact, appears to be one of the main characteristics that distinguish motor skills from other domains of learning. The evidence (Fitts & Posner, 1967, pp. 15–19) is to the effect that motor skills continue to improve with practice over long periods. As for retention, the differences favoring motor skills (Leavitt & Schlosberg, 1944) over verbal materials have often been confirmed.

2. *Verbal information* is a second category, surely of enormous importance for the schools. Facts, principles, and generalizations constitute a large portion of any curriculum, in most subjects. Such information is needed in a specific sense for continued learning within a particular subject area. Larger, organized bodies of information are usually called *knowledge*, and we recognize that people must acquire knowledge not only for further learning within a subject area, but for the lifetime purposes of learning across areas, and for thinking in a very general sense. The learning process for verbal information appears to be quite different from that of motor skills. Many theorists are now convinced that the repetition provided by

successive presentations of word lists on a memory drum is not the factor that causes learning (cf. Battig, 1968). Instead, the major requirement for learning and retaining verbal information appears to be its presentation within an organized, meaningful context (cf. Mandler, 1962; Rohwer & Levin, 1968), as the work of Ausubel (1968) also suggests.

3. *Intellectual skills* is a third category I would distinguish and I have written about these skills extensively (Gagné, 1970a). They are, most importantly, the discriminations, concepts, and rules that constitute the basic skills of the elementary curriculum, and all of the elaborations of these that occur throughout more advanced subjects. It seems particularly important to distinguish these from verbal information and knowledge. For example, being able to recall and reinstate a definition verbally is quite different from showing that one can use that definition. The latter is what is meant by an intellectual skill, but not the former. Do intellectual skills require practice for their learning? The evidence does not show that practice, in the usual sense of that term, improves them (cf. Gagné, 1970b). Does their learning require an organized, meaningful context? It is doubtful that it does, at least if one attempts to define meaningful context in the same sense as that required for learning verbal knowledge. Most importantly, the learning of intellectual skills appears to require prior learning of prerequisite skills, in a manner that is surely not true for learning verbal information. The absence of a necessity for particular prior learning is shown in the case of verbal information by studies of programming sequences such as that by Payne, Krathwohl, and Gordon (1967). For these various reasons, it seems essential to consider intellectual skills a domain of learning quite distinct from others.

4. *Cognitive strategies* is the fourth category, a domain that has been particularly emphasized by Bruner (1970; Bruner, Goodnow, & Austin, 1956). In a sense these are also skills, and they are obviously different from verbal knowledge. They are internally organized skills that govern the individual's behavior in learning, remembering, and thinking. Since they are directed toward self-management (cf. Skinner, 1968) of learning and thinking, they are obviously different from intellectual skills, which have an orientation toward the learner's environment. Although they are obviously very different from motor skills, curiously enough they share with them the property of deriving their learned organization from stimuli that arise within the learner. For this reason, they also require a kind of practice. The word is used here, though, mainly to emphasize the analogy; what appears to be required is repeated occasions in which challenges to thinking are presented. It is notable, therefore, that thinking strategies are not learned all at once, as intellectual skills may be. Instead, they exhibit continued refinement as the learner continues to encounter situations in which he has to learn, to remember, to solve problems, and to define problems for himself.

5. *Attitudes* constitute the fifth domain of learning. Their learning is obviously different from the other categories. They are not learned by practice. They are by no means dependably affected by a meaningful verbal context, as many studies have shown (Hovland, Janis, & Kelley, 1953; Rosenberg, Hovland, McGuire, Abelson, & Brehm, 1960). One of the most effective ways of changing attitudes would appear to be by means of the human model, and the "vicarious reinforcement" described by Bandura (1969). In any case, the apparent requirement for involvement of a human person in the process of modifying attitudes makes this kind of learning highly distinctive and different in many respects from the other varieties.

Generalizability and the Domains of Learning

The suggestion I make, therefore, is that when one deals with learning as a process, rather than as a set of content areas, one needs to distinguish the five domains of motor skills, verbal information, intellectual skills, cognitive strategies, and attitudes. These domains set the primary limits on generalizability of research findings concerned with learning. One can generalize *within* these areas, regardless of subject matter, with a fair degree of confidence. In contrast, generalizing across these domains is at best a highly risky business, and likely to be quite invalid.

Despite the suggestive evidence previously cited concerning the differences among these domains, one can hardly consider them as fully established. My suggestion is that it is these kinds of differences, and these kinds of implications for a generalization, for which the researcher needs to search. One cannot establish domains of learning by means of a few crucial experiments. Instead, conclusions about generalizability or lack of generalizability must be based upon a broad spectrum of findings from many content areas.

Suppose that one is concerned with how learning can be made most effective in a social studies unit on cities. If the objective is one of having children learn to state the names and locations of major cities of the world, the domain of learning is verbal information. The suggestion is that such an objective will be most readily achieved by providing a meaningful context for each city—for example, the semantic origin of its name, the reasons for its particular location, and so on. But if the objective of the unit on cities is a different one say, "deriving a definition of the concept city" (an objective requiring cognitive strategies), or "having a positive interest in visiting a city" (an attitude), the provision of a meaningful context for each city will not accomplish the desired learning. For these latter kinds of learning outcomes, something different is required in each case.

The objective of developing cognitive strategies for application to the defining and solving of problems pertaining to cities must be approached, according to the evidence currently available, by providing a series of learning experiences making possible a variety of opportunities for the student to think out solutions to novel problems, including problems that are not necessarily concerned with cities per se. He might, for example, have been provided with other defining problems, such as those of defining a person, or a group, or a school. But the presentation of meaningful contexts about cities is not what will effect this kind of learning, as it will the contrasted objective of "stating the names and locations of major cities."

Neither will the meaningful context accomplish the job of establishing or changing an attitude toward visiting the city. While one hesitates to say such a context has no effect at all, the evidence is quite substantially lacking that practically significant changes in attitude can be produced in this manner. But they probably can be produced by the modeling of human behavior. Perhaps the teacher, or some other respected person, can show his liking for visiting the city, and the student can observe the pleasure derived from rewarding experiences during such visits. Or, of course, he may be able to experience such rewards for himself. Both direct and vicarious reinforcement are likely to contribute to the establishment of a positive attitude.

The various objectives that have been described for a unit on cities are of course all different, and this is the point at issue. Any or all of these might be desired as an outcome of such an instructional unit. The suggestion from research is that these different learning outcomes require different conditions for effective instruction. The question for research is to verify the generalizability, and the absence of generalizability, of learning conditions and learning outcomes across these domains.

Another example may be useful. Suppose one wishes to offer students a science unit on Moments of Force. The likelihood is, in this case, that the major concern is with an intellectual skill such as "demonstrating the equivalence of moments of force about a fulcrum of a body at equilibrium." Such a learning task is best described as the application of a general rule to a specific situation, novel to the learner. Naturally, the learner has to be given specific verbal information (about the body, the fulcrum, etc.) in order to attack the problem. Just as obviously, he may have learned some ways of defining and approaching such problems that deserve to be called cognitive strategies. But the critically necessary capabilities he must bring to the task are the intellectual skills that include rules for obtaining moments of force, of multiplying specific values of force and distance, of substituting values in statements of equality, and the like.

How are such rules learned? The conditions for their learning are not the same as those for verbal information, nor are they the same as those for cognitive strategies. According to my interpretation of the existing evidence, the critical condition for their learning is the recall of previously learned intellectual skills (subordinate rules, concepts, etc.). As a further consideration, it may be noted that when one attempts to assess the learning of such skills, one does not set about measuring what factual knowledge (verbal information) the student has, nor how well he formulates the problem (cognitive strategies). Instead, one tries to measure the possession of the intellectual skill—whether or not the learner is able to apply the rules he has acquired to this class of problems.

When these five domains are identified as the primary categories that limit the generalizability of conclusions about the learning process, does it not suggest that some other rather obvious human characteristics are being overlooked? For example, is it possible that sex or racial characteristics may impose such limitations even more clearly? Concerning these variables, it seems unlikely to me that they are the kinds of factors that biologically limit the generalizability of propositions about learning, although some investigators wish to explore this possibility (cf Jensen, 1968). The variable of age, however, may be a good one to consider further in the present context, since it may serve to show not only what the differences in learning are, but why they may be expected to occur.

Age and Learning

Let us consider two students, both of whom are attending school. One is 10 years old, in the fourth grade; the other is 24 years old, and attending graduate school. Is there a difference in the way they learn?

First of all, there are obvious differences in the arrangements made for their instruction. The fourth-grader is learning how to use his language, in speaking, reading, and writing. He is learning to use mathematical concepts and to solve quantitative problems. Perhaps he is learning also about different nations and cultures of the world. Many of these things to be learned are prescribed as part of a school curriculum. The graduate student may also have some prescribed subjects to deal with—foreign languages, or statistics, or computer usage. It is perhaps relevant to note that much of what he learns is determined by him, because he sees the need to learn it—the knowledge of how a specialized field is conceptually organized, of its methods, and of its ways of formulating and solving problems.
There are, then, some differences in the kinds of choices that the learner makes, in these two cases, and in the kinds of objectives being pursued, although perhaps not major ones. The 10-year-old is learning how to do some arithmetic, the 24-year-old is learning how to do some statistics. The 10-year-old may have a choice of a South American country whose culture he wishes to explore; the 24-year-old chooses a particular field of research whose findings he wishes to organize. But how do they go about their learning? Are there differences here?

There are, and they are quite striking ones. In the case of the arithmetic, for example, the fourth-grader is responding to a carefully organized plan of instruction, which provides him with illustrations, a rationale or verbal explanation, some chosen examples, and a means for him to check his operations at frequent intervals. He responds to printed text, to some pictorial presentation, and to the oral communications of the teacher. Arrangements are made for spaced reviews, and for application of the principles he learns in a number of verbally described situations. In the case of the statistics, the graduate student meets quite a different set of circumstances. Mainly, he is expected to learn by reading a book chapter by chapter, by following its terse rationale, and by applying what he has learned to problems containing detailed quantitative data. The book does not provide him with many pictorial aids, nor does it furnish lengthy explanations of procedural steps.

Similar contrasts exist in the learning about a foreign country's culture by the fourth-grader, and the learning of the substance of a field of research by the graduate student. The 10-year-old learns the features of a foreign culture when they are carefully embedded within a meaningful context, which he learns about partly by reading, partly by using audiovisual aids, partly by the teacher's oral communications. Sometimes, in fact, this meaningful context becomes so rich that it is difficult to tell what he is supposed to be learning. The graduate student, in contrast, does a great part of his learning by reading articles in professional journals or technical books. They seldom can include a meaningful context or background since that would require too many pages, and they seldom include diagrams or other pictorial aids, since they cost too much. The sentences and paragraphs he reads tend to be long and densely written, and they refer to many abstract and technical concepts.

Both of these provide examples of learning, and both may be effective learning. Yet if one were to study what made learning effective in the 10-year-old, would one be able to generalize to the 24-year-old? I think not. The difference in the two instances is often summarized by saying that the 24-year-old has become to a large extent a self-learner, whereas the 10-year-old has not yet achieved this state, and has a ways to go before he does.

What might "being a self-learner" mean? What does the graduate student bring to his learning task that differs from what is brought by the fourth-grader? It seems to me that this question can best be answered in terms of the five domains of learning I have described.

The 24-year-old has acquired much complex, highly organized verbal information in his field of study. Accordingly, he is able to supply the meaningful organization required when he reads the journal article that is so concisely written. The 10-year-old has no such store of verbal information about the cultures of foreign countries, or even perhaps about his own country. The meaningful organization he can bring to bear on the learning task is therefore meager, and we must take a variety of means to supply it for him.

The 24-year-old has some highly relevant intellectual skills, which he has used many times, in approaching the study of statistics. He can perform mixed arithmetic operations, interpret graphs and tables, state and solve proportions, use the concepts of area and of limits. In the case of the 10-year-old, one is not so sure he can recall the prerequisite skills to the new operations he is learning in arithmetic. One therefore takes care to arrange the situation so that these intellectual skills are recalled, and also attempts to insure by means of spaced reviews that the new ones he learns will be readily available in the future. Another kind of difference in intellectual skills is exhibited in language usage. The graduate student is able to respond appropriately to the compact and complicated sentences of text he encounters in his reading, whereas the fourth-grader would be confused by these.

The 24-year-old brings to his learning task some highly valuable cognitive strategies, which the 10-year-old has not yet acquired. The former is probably able to sort out main and subordinate ideas in his attending and in his reading. He may well have some techniques of rehearsal that act in the storage of what is learned, as well as efficient strategies for retrieval of previously learned knowledge and skills. And he almost surely has acquired and refined some ways of approaching problems, defining problems, and weighing alternative solutions to problems—ways that are available only in a primitive form to the 10-year-old.

In terms of these domains alone, there are likely to be enormous differences in the process of learning in the 10-year-old and the 24-year-old individual. These differences exist, not simply because the passage of time has produced a disparity of 14 years in their ages or stage of biological growth and decay. They exist because of a history of learning, which has left in the older person a residue of increased knowledge, a greater repertoire of intellectual skills, a greatly enhanced collection of cognitive strategies, and quite probably a different set of attitudes. All of these capabilities are different in the two instances, and each of them is bound to affect the process of learning, so that a very different problem exists for the design of instruction for these two individuals.

Is it possible that I have distorted these differences by choosing a graduate student as the 24-year-old, rather than an adult who is a high school graduate? The differences may be magnified, surely, but not distorted. If one equates inherent intellectual capacity, the typical adult is likely to outdo the 10-year-old in amount of verbal information he has, either in general or specialized fields. He is very likely to have more powerful cognitive strategies, particularly as these relate to his capabilities of problem-solving and thinking. As for his intellectual skills, these are most likely to display a very uneven picture, since they can rather readily be forgotten unless they are used constantly. For example, unless there are occasions for use in the intervening years, such an adult may well have forgotten how to add fractions, or to find a square root, or to edit written sentences to make verbs agree with subjects. It would not be surprising, therefore, to find a number of specific instances of knowledge or intellectual skill in which the fourth-grader displayed greater capabilities than the young adult. Such instances, however, merely seem to verify the general proposition that the five categories I have described represent the critical dimensions of domains of learning within which generalization is possible. It is of little use to know that some fourth-graders know how to do some things that some adults do not; this is not at all a remarkable fact. But it is of use to know, particularly if one is designing adult education, the nature of the adult's capabilities in the different domains of learning.

It is of some interest to point out some implications of this analysis of age differences in learning. First, it becomes apparent that college and university courses are not good models for the design of instruction for the fourth grade. A laboratory exercise in college chemistry, for example, cannot be made into a suitable learning experience for a child simply by using simpler language. Although the verbal information contained in the exercise may be made understandable to the child, it is quite another matter to attempt to reduce age differences in the domains of intellectual skills and cognitive strategies. The latter capabilities must be learned, and if one sets out to teach them to the fourth-grader, it is likely to take some time, possibly even years of time. A second implication is the reverse of the first; the design of instruction for the 10-year-old is not a good model for college instruction. Suggestions are sometimes made along these lines with reference to the education of teachers. However, as suggested by the previous analysis, the college student brings to his instruction a great variety of knowledge, intellectual skills, cognitive strategies, and attitudes that the 10-year-old simply does not have. If one attempts to design instruction for the college student that assumes that these capabilities are not there, it will surely be perceived as both boring and ridiculous. What is needed instead is a clear recognition of the requirement for different instruction for the fourth-grader and for the college student, based upon expected age differences in the different domains of learning.

Conclusions

The ideas presented in this article are expected to be of primary interest to those who perform research on learning and instruction, and to those who attempt to base instructional procedures upon the findings of such research. An examination of the results of studies of learning, particularly those concerned directly with school subjects, strongly indicates the necessity for recognizing five major domains of learning. These are here named motor skills, verbal information, intellectual skills, cognitive strategies, and attitudes. It appears likely, on the basis of present evidence, that generalizations about the critical conditions for learning, as well as about the outcomes of learning, can be validly made within these categories (irrespective of specific content), but not across them. Further validation of this proposition must of course come from a great variety of research evidence; therefore, the categories as now formulated may serve as points of emphasis in studies of school-subject learning.

Considerable usefulness can also be foreseen in the application of these categories in instructional design. In such use, the domains are classes of instructional objectives, each of which requires a different set of critical conditions to insure efficient learning, and each of which implies the need for a different sort of situation for its assessment as a learning outcome.

Examples of the generalizability of learning characteristics within domains and their non-generalizability across domains have been described. An example of age differences in learning between a 10-year-old and a 24-year-old is expanded to clarify the implications of learning domains. The major argument put forth is to the effect that differences in the requirements of instructional design cannot be clearly understood simply by appeal to differences in biological growth or amount of experience. The older and younger learner begin their learning of a new task with particular differences in previously acquired verbal information, intellectual skills, cognitive strategies, attitudes, and motor skills. Depending on what the new learning task is, the younger learner may begin the learning with greater or lesser capabilities than the older learner, in any of these categories. Effective instruction needs to be designed to take full account of the differences within these learning domains.

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Chapter 4

Mastery Learning and Instructional Design[6]

Robert M. Gagné

One of Gagné's major contributions to theory and practice alike was the Events of Instruction. The Events serve as a major vehicle for incorporating the conditions of learning into an instructional situation, and serve as a framework for the design of lessons. The Events were primarily discussed in Gagné's book-length publications. This article is one of the few shorter summaries of the Events of Instruction and their rationale. It was published in 1988 in the premier issue of Performance Improvement Quarterly, over 20 years after the original introduction of the Events of Learning in the first edition of Conditions. It provides Gagné an opportunity to compare his position, as well as the role of instructional design in general, with that of Benjamin Bloom.

Recounting a little of my personal history, I was at one period strongly attracted to the idea of programmed instruction. I supervised a program of training research that included the advocates of both linear program design and branching program design. A little later, I conducted learning studies that utilized programmed materials as their principal content did. The reason I bring these things up is simply this: The idea of learning to mastery was (at least for me) first encountered in programmed instruction. It was quite clear that instructional programs, with their frames and small steps, were aiming for performance that was perfect. That is, the criterion of learning was complete learning, without error, with a criterion of 100%.

Mastery Learning

It took the brilliant insight of Benjamin Bloom (1968) to raise this particular feature of planned instruction to a new level of generality. Using some of the distinctions of Carroll's model of school learning (1963), he proposed that learning to a criterion of 100%, or *learning for mastery*, should be not only a desirable, but also an attainable goal for all but a very small percent of students in school programs. Mastery should be achievable for virtually all students, provided suitable provisions can be made in the time allowed for learning and provided that the *quality of instruction* be held at a high level. This quality should include provision for formative evaluation testing (of the students) and for feedback to them.

In the writings of Bloom, then, mastery learning was transformed from a virtually adventitious feature of programmed instruction to a major desirable characteristic of instruction in general. There came to be strong reasons why instruction should abandon a standard like "70% is passing." Such a statement means that some things have been learned and some have not, whereas the aim should be that all of the objectives of instruction are mastered.

Still another source of influence on these ideas must surely have been the notion of criterion-referenced measurement, as described by Glaser (1963) and by Glaser and Klaus (1963). In this kind of assessment, measurement is made of the attainment of some defined performance. That is, the measurement of performance is related to some standard, or criterion. It is perhaps worth noting here that the clearest examples of criterion-referenced measurement come from kinds of learning outcomes called intellectual skills, such as those pertaining to the learning of mathematics, grammatical rules, science principles, and the like. Criterion-referenced measurement of such subjects as history and literature presents some considerable difficulty, which has not as yet been solved satisfactorily. That is an important point, for the following reason: Mastery learning means 100% learning. As long as the 100% criterion can be maintained, the concept of mastery learning is clear and strong. Once one departs from that standard (as is often suggested by scholars in the psychometric tradition), the fundamental meaning of "criterion-referenced" is lost, and the idea of mastery learning suffers severely. But consider these remarks, if you wish, only a footnote.

The next step in mastery learning, as I have perceived it, was to make it into a system of instruction. This effort was contributed to by the studies of Anderson (1976) and Block (1974), among others. These studies contributed the idea that large differences in achievement found in typical school classes could be substantially reduced by allowing slower students more time, and by assuring that all students received feedback coupled with corrective instructions. Thus, when teachers were committed to making these adjustments in their delivery of instruction and in their classroom procedures, the level of achievement in the whole class improved. Students who would otherwise be in the lower part of the distribution were allowed and encouraged to catch up, to restudy, to follow new procedures, even when they took more time, and thus to become "good students" rather than poor ones.

Soon it was time for Bloom to lay it all out—to disclose the master plan. This he did in the book titled *Human Characteristics and School Learning*

(1976). Here we are told that outcomes of learning are determined by two kinds of characteristics of students upon entry into instruction—*cognitive* capabilities and *affective* characteristics. Obviously these are influenced by prior instruction in the school, but in major respects by the extra-school environment—the home and the community. Then, we come to the influence of instruction itself, that is, to the *quality of instruction.*

Evidence collected and summarized by Bloom indicates that quality of instruction in such subjects as mathematics and foreign language has to do with the following variables: (a) the cues or directions provided to the learner, (b) the participation of the learner in the activity, (c) the reinforcement received by the learner, and (d) the provision of feedback that includes correctives. It is of interest to note that cognitive entry characteristics enter into the picture, also, in the specific sense of *prerequisites to the learning task.*

It is these ideas about quality of instruction, specifically, that I shall want to return to again in reviewing the ideas of instructional design. It is these variables that Bloom designated as *alterable variables.* These are the factors that the designer of instruction, or the teacher, is able to alter, and in so doing, is able to affect the quality of instruction.

More recent verification of the effects of these variables of instructional quality has come in the article by Bloom on "the 2 Sigma Problem" (1984). In this article, studies by several of Bloom's students examined the improvements in achievement over conventional classroom instruction of variables identified as (a) enhancement of prerequisites, (b) enhanced cues and participation, and (c) mastery learning feedback and correction procedures. The latter procedures were also tried in combination with other variables, including a total set that made up a complex called "tutoring." While I do not wish to describe the results in detail, I would say with emphasis that every one of these "alterable variables" was shown to have a positive effect on achievement. Of course, some effect sizes were larger than others. Furthermore, their combined effects appeared to be additive.

What Bloom wishes us to note is that some of the most obvious quality features we can observe in a one-to-one tutoring situation are also useful quality features with classes of 30 students. If teachers make up their minds to do so, the features of enhanced prerequisites, enhanced cueing, student participation, and feedback providing reinforcement and correction, can all be done in the classroom. And if the designers of instruction decide to do so, these same quality features can be built into the instruction delivered by virtually any of the media. These are the variables of instructional quality, and in combination with the procedures of mastery learning, they can raise achievement by an amount of two entire sigma.

What About Instructional System Design?

In proceeding to a consideration of the features of instructional system design (ISD), I shall be speaking about the rational basis for this model of instructional design, not about the design procedures themselves. For example, I shall not be talking about "how to do a task analysis"; not "how to introduce a new concept," but, "the ways in which instruction can influence the learning of a new concept." As I proceed with the presentation of instructional design ideas, you will see, I think, the following points of comparison with learning for mastery:

1. There are some striking main ideas of mastery learning and instructional design that are identical (except for terminology).
2. There are a few key points of ISD that are not shared with mastery learning.
3. I can detect zero points of conflict in the instructional recommendations from the two systems.

Instructional Design

Instructional design begins with what is called a needs analysis, the purpose of which is to determine what needs to be learned. (I shall not expand upon this subject here.) This is followed by a task analysis that states what is to be learned as a set of performance objectives. These are specifically stated descriptions of observable human performances. There may need to be many descriptions for any particular course of study, and almost certainly several for any given lesson. An example, for a course in science, might be: "Given a printed description of a body falling from a specified height, demonstrates the principle of gravity with an expression yielding the value of the force at earth's surface." A different kind of objective, also for a course in science, might be: "Describes the succession of steps in scientific knowledge and logic that led to the abandonment of the concept of the *ether*."

Assuming that such objectives do exist, or that they can be stated, the next step is to classify the objectives. I need to say more about this later. At this point I simply note that objectives are classified as *types of learning outcomes*: verbal information, intellectual skills, cognitive strategies, attitudes, and motor skills. The reason for classifying objectives is not primarily because they have to be assessed (or measured) differently. This is fairly obviously true. The main reason for classifying learning outcomes, though, is because *they require different instruction* for greatest effectiveness. This point comes up later, after I have outlined the tactics of instruction in general.

Instructional Tactics and Their Sources

The tactics of instruction are derived from two different sources, two sources that are fortunately found to be compatible and even complementary. One source is simply observation of what instruction does—how it proceeds in its attempts to teach. This is not exactly "what an instructor does," or "what a teacher does"—it is narrower in conception. It is "what a teacher does in delivering instruction," or "what a textbook does in delivering instruction." However limited these tactics may be in temporal duration, there is a series of steps—a procedure—in the structure of instruction.

A second source is learning theory. The model of information-processing proposed by Atkinson and Shiffrin (1968) some years ago identifies a number of conceptual structures involved in the process of taking in information and getting it transformed so that it is stored in long-term memory and later recalled as an observable human performance. This entire process, or set of processes, forms the basis of what I refer to when I speak of learning theory. The sequence of processing when something new is learned is briefly described in the following section.

Information Processing for Learning

Following reception of incoming stimuli, information is *registered* very briefly in one or more sensory registers, then undergoes *feature analysis or selective perception.* The information next enters short-term memory where it can be *stored* in limited amounts for only about 20 seconds. Here it may be *rehearsed* and is also subject to *semantic encoding*, in which form it enters the long-term memory. Information from long-term memory may be *retrieved* back to a short-term form, which is in this case viewed as *working memory.* Working memory (conscious memory) is where various combinations of new and old information take place, and so provides a very important *working* function for new learning. The additional output of long-term memory, of course, is the response system itself, yielding performance that can be observed outside the individual.

Two other aspects of this information-processing model need to be mentioned. One is that an important component is *executive control*—a means by which the learner exerts control over the other processes of learning and memory. The learner may exercise executive control, for example, over the allocation of attention, or over the process of rehearsal, or over the way incoming information is encoded. A second additional feature is the process called *reinforcement.* Although the model I have described doesn't tell us how reinforcement takes place, it assumes that it *does* take place. In other words, the *law of effect* is assumed to prevail in any act of learning. The after-effects of successful performance have their well-known effects on subsequent performances.

I emphasize again that the Atkinson-Shiffrin model of information processing—and there are other, contrasting, models—implies that learning involves a *sequence of steps—a sequence of transformations of information from one form to another. Thus, this model conceives that learning is a step-like series of processes. All of them may occur in a few seconds, but they nevertheless constitute several identifiable stages.*

What do these internal learning processes have to do with instruction? Instruction, after all, is a set of external events. Can these be thought of as bringing about the internal events we call learning processes? Well, not really. External events do not directly cause the internal processes. But they may be shown to *influenc* them, to *support* them. This leads to the idea that instruction may be defined (to quote myself) as "a set of deliberately planned external events designed to support the processes of learning" (Gagné, 1985).

The Events of Instruction

The two sources—empirical observations of the procedures of instruction, and the information-processing model of human learning and memory—are both involved in the formulation of the events of instruction. These events are as follows, arranged in the usual sequence of instruction:

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prior learning
4. Presenting the stimulus
5. Providing learning guidance
6. Eliciting the performance
7. Giving informative feedback

8. Assessing performance
9. Enhancing retention and transfer

I hasten to point out two caveats about these nine events. First, the order of their presentation is not always followed exactly, even though in some ways it is inherent. (One cannot give feedback until the performance has been made.) Second, depending upon the age and experience of learners, not all the events are always overtly employed in instruction. For example, for students of arithmetic who have been exhibiting the required performances of adding fractions, it would almost surely be a waste of time to go into detail about the next objective "subtracting fractions." In general, however, my hypothesis about these events would run something like this: Each of the events of instruction is capable of supporting internal processes of learning. Unless such support is provided by the learner's own executive control, the presence of each event adds to the probability of successful achievement.

How These Events Relate to Mastery Learning

Let me now elaborate somewhat on some of these that appear to be relevant to learning for mastery.

Stimulating Recall of Prior Learning

Certainly this is the same as what is meant in the studies of Bloom's colleagues and students as *enhancement of cognitive prerequisites*. In my own writing, when I am dealing with instruction for intellectual skills (as they may occur in mathematics and foreign language learning), I say that the most important condition to assure is that prerequisite skills be retrieved so that they are in the forefront of memory, in other words, prominently attended to in working memory.

Presenting the Stimulus

This event is considered to be the occasion for emphasizing or highlighting the distinctive features of what is to be learned. If learning is from a printed text, then key ideas may be underlined, printed in bold type, set off on the page, or whatever. If valves of the heart are being studied, then pictures showing these valves in bold outline may be employed. In general, features of what is presented are made distinctive in order that they may become cues. Here is one meaning for Bloom's phrase "enhanced cues."

Providing Learning Guidance

In instructional design, learning guidance covers quite a lot of ground, depending on what kind of learning outcome is expected. In the simplest case, it can mean simply "hints" and "prompts," and thus be another way of providing proper cues. More generally, learning guidance means *organizing* and *elaborating* the content. These activities may be done by the instruction itself (as designed by the instructional designer) or they may simply be suggestions that they be done by the learner. Advance organizers are an example of the former. An example of the latter might be a suggestion like "In learning the names of all the states, think of their locations in terms of the areas of an imagined map." Questioning is another way of suggesting an organization to instructional content, and again this may be done by asking the student to construct questions to be answered. In summary, the event called "providing learning guidance" has in it the ideas of *cueing*, or *organizing*, and of *student participation*.

Eliciting the Performance

Of course this is done to verify that something has been learned. However, it probably also should be related to student participation. In a minimal sense, students need to participate by showing what they have learned.

Giving Informative Feedback

Furnishing feedback is surely one of the critical events of instruction. The phrase "informative feedback" is used to reflect the research findings of Estes (1972) who demonstrated the superiority of information vs. reward as a form of reinforcement. This event is consistent with the feedback concepts of mastery learning. However, "corrective feedback" as employed in mastery learning, implies a somewhat more elaborate procedure in which the learner is instructed in ways of correcting his errors.

Others

There are a few more parallels that could be drawn, but they are less important than those I have mentioned. It appears to me that if instructional designers used the events of instruction properly, they would be incorporating into the lessons they design the ideas of (a) enhancing prerequisites, (b) providing content organization and cues to retrieval, (c) assuring student participation, and (d) using informative and corrective feedback. Thus, the instructional designer who follows this model would be taking advantage of the *alterable variables* identified in the studies of Bloom and his students. Such instructional design would be expected to make the most of the kinds of variables that lead to effectiveness of learning in the one-to-one tutoring situation.

Differences in the Two Systems

There are, then, substantial similarities, or even identities, between the design implications desirable from the research on learning for mastery and those that are characteristic of instructional systems design. There are also differences, some that are probably minor in their effects, and one that is major.

An example of a minor difference, which I nevertheless believe is worth attention, is event No. 2, "informing the learner of the objective."I realize that the evidence on this variable is mixed. Nevertheless, it is obviously the kind of event that would normally be a part of a tutor's behavior. My guess is that it will be found to have an effect size of at least .30 in a properly designed study. The investigation of Rothkopf and Kaplan (1972) is one good example.

Taxonomic Differences

But let me turn to the major difference. Curiously enough, this difference pertains to the taxonomy of objectives—the taxonomy of learning outcomes, and the implications this taxonomy has for instruction. Both Bloom and I have taxonomies of learning outcomes to propose, and there are some categories about which there are no differences in any major sense. I would surely agree there are domains of cognitive outcomes, affective outcomes (which I call attitudes), and psychomotor outcomes. Here, then, are the differences I see:

1. I think it is necessary to distinguish *three kinds of cognitive outcomes.* These arise from learned capabilities that are qualitatively, structurally, different from each other. They are called verbal information, intellectual skills, and cognitive strategies. Some relationships can be built between these and the six kinds of outcomes in Bloom's cognitive learning theory. These three types are called declarative knowledge; procedural knowledge, or productions; and self-management skills, or control processes. I will say in a moment why I think these distinctions are important.
2. Each of the five learning outcomes—intellectual skills, cognitive strategies, verbal information, attitudes, and motor skills—*requires a different specific content and configuration* of instructional events for effective learning. It is perhaps easiest to make this point by taking as examples two kinds of outcome that are most unlike—verbal information and motor skills. The provisions of the U.S. Constitution regarding the powers of the executive branch may be taught either by auditorially delivered speech, or by print on a page. But these media have extremely limited usefulness in teaching a motor skill. You do not teach letter-printing or ice-skating by talking about them or requiring someone to read about them. Surely everyone would agree that, in the case of these two types of learning outcomes, the

instructional designer or teacher has to do different things so far as the operations of "enhancing prerequisites" and "providing cues for retrieval" are concerned. Feedback and correction also have to be quite different in the two cases—feedback for a motor skill must be very precise, whereas feedback for a passage of prose can be quite imprecise, so long as the "gist" is recalled.

Different Learning Conditions for Different Outcomes

These differences in two contrasting kinds of learning outcome also imply a requirement for distinctive learning conditions. And so, upon further analysis, distinctive instructional conditions for each of the five different kinds of learning outcome becomes one of the major conceptions of instructional design theory (Gagné, 1985). These distinctive conditions can be expressed in terms of the events of instruction previously mentioned. The differences show up primarily in the events numbered 3, 4, and 5—stimulating recall of prior learning, presenting the stimulus, and providing learning guidance.

Recall of Prior Learning. When intellectual skills are to be learned, the prior learning to be recalled consists of prerequisite skills. This, of course, is in accord with the idea of "enhancing prerequisites." But when verbal information is being learned, the prior learning is not exactly prerequisite. It is, instead, a larger complex of organized knowledge. This is the meaningful structure spoken of by Ausubel (1968), or, in terms of modern cognitive theory, the schema. This knowledge is not precisely pre-requisite, and is much more generally related to verbal information than are the prerequisites of intellectual skills. When motor skills are the outcomes of interest, the relevant prior knowledge may be either the procedural skill called the executive subroutine, or part skills of some sort. But part skills, when they can be identified are not prerequisites. Then, when an attitude is being acquired, the prior learning is still different. It may include knowledge of the situation in which the attitude is to be displayed. Also, it needs to include reminders of a human model and the qualities that make such a person admirable.

So, what is meant by the prior learning which is to be stimulated, or enhanced, is very different depending upon the nature of the learning outcome.

Presenting the Stimulus. This instructional event is obviously going to differ depending on what learning outcome is expected. For example, if the aim is learning conversational Spanish, the stimulus must comprise orally produced Spanish speech, and it would be a mistake to present printed text in its place. But, beyond this, the differential aspects of stimulus presentation pertain to emphasis on *distinctive features*, and therefore on the means of providing *cues*. Cues for the recall of meaningful prose passages are probably quite different from cues for the recall of concepts and rules. Distinctive features of printed discourse would appear to be key words and phrases, topic sentences, and the like. For intellectual skills, in contrast, distinctive features are likely to be cues of the *sequence of steps* involved in procedures to be recalled. For example, cues for the successive steps in long division are usually given emphasis in the stimulus presentation for this skill.

Learning Guidance. What is meant by learning guidance is also different for different kinds of learning outcome. According to most theoretical accounts, verbal information learning may best be enhanced by procedures called *elaboration*, that is, by relating new knowledge to be learned to larger masses of organized knowledge that are already familiar. Learning about a particular event of a political campaign is acquired and stored in relation to a larger set of knowledge, a schema, pertaining to political campaigns in general. However, it is not at all clear that elaboration is the way to deal with intellectual skills. Concepts and rules must yield performances of great precision, and it is possible that such a quality is not promoted by elaboration. Learning guidance for procedures usually means making their steps distinctive.

Images also appear to have different functions in the cueing of verbal information and intellectual skills. It is notable that images have been shown to be useful in recalling disparate, non-meaningful items or lists of verbal information, whereas their use as cues to intellectual skills is much less well established.

Summary of Differential Instructional Events. The general point, therefore, is that the alterable variables called enhancing prerequisites, stimulus organization, and cueing, are entirely compatible whether one follows the principles of learning for mastery or those of instructional systems design. The latter theory, however, requires that attention be given to the *differential* qualities required for the events of instruction called "stimulating recall of prior learning," "presenting the stimulus," and "providing learning guidance."Distinctions between the cognitive outcomes called verbal information and intellectual skill are of critical importance.

As for other instructional events of instructional design, they appear to be quite identical with those advocated by the mastery learning conception. Here I speak particularly of reinforcement, informative feedback, and corrective information. Mastery learning has continued to emphasize these features of effective instruction. Bloom and his students have verified their worth in a number of studies of classroom instruction.

A Noteworthy Area of Agreement

I want to point out one aspect of learning on which there is a marked measure of agreement, because it seems so important. This is the idea of skill automaticity. Bloom has written about this conception (1986), and I have too (Gagné, 1983). Intellectual skills that are highly practiced come to be performed automatically, that is, they demand little conscious attention. The skilled student of geometry doesn't have to "stop and think" about how to find the value of the complementary angle of 100 degrees—instead, its value of 80 degrees is known automatically once its direction and origin are perceived. The skilled reader does not slow his comprehension in order to pay conscious attention to the differences between *welcome* and *winsome*, because the differences in their sounds are automatically processed. The skilled writer doesn't stop to attend to the form of a past participle of the verb go, but writes automatically, "I have gone."

By definition, a skill becomes automatic when it can be performed without interfering with a second simultaneous task. In practice, automaticity is achieved by repeated performances in different examples. For instruction, one of the best procedures appears to be involving learners in game-like exercises in which they strive to beat their previous times in performance of a skill.

The main importance of automatization of skills lies in the freeing of attention for other tasks, particularly those that require problem solving. Thus, reading comprehension depends on the automatization of decoding skills, so that the "thinking" part of reading can be done. The solving of arithmetic word problems depends on the automatization of skills of mathematical translation in order that attention be made available for problem solving activity. Skillful automobile driving likewise requires the presence of automatized component skills of acceleration, braking, and steering. Here is the way I would state the most important hypothesis in this area:

> The *principal factor* affecting the development of higher level thinking in learners is the release of attention by automatization of basic skills.

Conclusion

I conclude by saying that the principles of instructional design have a great deal in common with those procedures advocated and validated for mastery learning. There are scarcely any important conflicts between the two systems that I can detect. Both are concerned that designers and teachers make use of the alterable variables for which there is much evidence:

enhancing prerequisites, providing good stimulus organization and cues, assuring learner participation, giving feedback with correction. Their similarities even extend to a mutual appreciation of another kind of variable whose importance has not always been given sufficient emphasis—automatization of intellectual skills. This might, I suppose, be classified as an additional example of the need for learner participation—a participation that goes beyond initial learning, and perhaps also beyond what is usually considered "mastery."

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Chapter 5

Integrative Goals for Instructional Design[7]

Robert M. Gagné and M. David Merrill

In 1987 Utah State University hosted a dialogue between Robert Gagné and David Merrill. The notion of enterprise schema and integrated goals emerged from these discussions. The idea was subsequently expanded and published in 1990. It responds in part to those in the field who have criticized the vestiges of behaviorism in much design practice, specifically the continued tendency in some quarters to emphasize instruction directed toward fragmented factual information. This article not only shows the relationships between the work of Gagné and Merrill, but it provides the last major addition to Gagné s explanation of his taxonomy of learning outcomes. Moreover, it reinforces Gagné's lifelong concern with transfer of training that has been evident in each of the five articles presented here.

[7] *Editor's Note:* Reprinted from 'Integrative Goals for Instructional Design," by R. M. Gagné and M.D Merrill, 1990, *Educational Technology Research and Development*, 38 (1), 23-30. Copyright 1990 by Association for Educational Communications and Technology, Washington, DC. Reproduced by permission of the Association for Educational Communications and Technology.

One of the signal accomplishments of contemporary doctrine on the design of instruction, whether considered as model or theory (Reigeluth, 1983), is the idea that design begins with the identification of the goals of learning. Goals are sometimes conceived as objectives reflecting human performance, and sometimes as learning outcomes implying the acquired capabilities for those performances. In either sense, the goals which are projected to result from learning are presumed to be the starting point of the process of instructional design. Having distinguished these goals, the designer proceeds by iteratively posing and answering the question, "What is it that must be learned for the learner to reach these goals?" In this article, we deal with the requirements for design when the instructional goal must be a combination of several individual objectives that are to be integrated into a comprehensive purposeful activity (such as baking a cake, writing a letter).

Regardless of differences in terminology and style, there are many common features to models of instructional design. The procedure of working backwards from goals to the requirements of instructional events is one of the most effective and widely employed techniques. This approach requires the initial identification of a category of instructional objectives, such as *verbal information, intellectual skill, cognitive strategies* (Gagné, 1985) or alternatively the remembering, using, or finding of *facts, concepts, procedures,* or *principles* (Merrill, 1987). From each of the single categories of learning outcome, the designer is able to analyze and prescribe the instructional conditions necessary for effective learning.

In using this procedure, the designer is working with single objectives and must therefore plan instruction for content that is circumscribed in coverage at the level of an individual topic, or at most a single lesson. For example, the topic of legislative powers vested in Congress (Article 1, Section 1) may be identified as *verbal information* in a lesson on the U. S. Constitution and its instruction planned accordingly. The algebraic addition of polynomial expressions might be the subject of a lesson consisting of the learning of one or more *rules*. The derivation of instructional design procedures from such objectives as these is usually straightforward and clear.

When instruction is considered in the more comprehensive sense of a module, section, or course, it becomes apparent that *multiple objectives* commonly occur. A student seldom learns about the legislative powers vested in Congress in isolation. Usually the module or section of the course is concerned with the way Congress operates to make laws. Not only are new facts introduced, but new concepts must be acquired, and new principles of government understood. Polynomial expressions must be seen to be subject not only to the procedure of addition, but also to those of decomposition, and in the context of real world problems for which these mathematical operations provide a solution tool (Brown, Collins, & Duguid, 1989). A lesson on as familiar a subject as plant growth may readily involve verbal information concerning plant names and varieties, the concept of plant parts, and some rules about plant growth. When the comprehensiveness of topics reaches a level such as often occurs in practice, instructional design is forced to deal with multiple objectives and the relationship among these objectives.

Planning instruction for more than one objective may sometimes be simply a matter of designing instructional procedures for one after another in sequence. This is particularly evident in topics composed primarily of intellectual skills, in which a lesson such as addition of simple fractions may be followed by a lesson on improper fractions, and followed again by one on simplification of fractions. Such a linear sequence of single objective lessons may not be so evidently satisfactory for multiple objectives, however, since it fails to assist the learner in the acquisition of interrelationships among the various component objectives. This is the case, for example, when one is dealing with content like the legislative powers of Congress, which contains many facts, new concepts, and novel rules.

Article 1, Section 1 states: "All legislative powers herein granted shall be vested in a Congress of the United States, which shall consist of a Senate and House of Representatives." For some learners, this statement might be dealt with simply as a piece of verbal information. But such a single objective cannot be adequately employed to describe what needs to be learned by the typical high-school student in a course on American government. Such a student, in order to acquire the understanding that is desired, must at the very least either retrieve or newly learn the concepts named by the words of the sentence: *legislative, powers, vested, Congress,* and so forth. These several objectives could conceivably be reflected in instruction in a serial, one-at-a-time fashion. Yet there is room for doubt that this approach would be the best that could be devised. Instead, it seems possible that some *integration* of these objectives might be conceived as a way of expressing a combined goal. Such an integration would not replace the multiple objectives that make up a module or course goal, but instead would actually incorporate the several different objectives.

Integrating Multiple Objectives

In seeking a way of dealing with multiple objectives other than serially, we perceive a need for treating human performance at a somewhat higher level of abstraction than is usual in most instructional design models. People may learn facts, but what for? They may learn new concepts, but how are these to function in the context of the larger task that they as human individuals do? Learners can acquire procedures, but in the context of what larger scale activity? Performances may be described, not simply as steps in a sequence but also in terms of their function and purpose in meeting the goal of an activity as a whole.

We propose that the integration of multiple objectives may usefully be conceived in terms of the more comprehensive activity in which the human performer is engaged, which we call an *enterprise.* An *enterprise* is a purposive activity that may depend for its execution on some combination of verbal information, intellectual skills, and cognitive strategies, all related by their involvement in the common goal. A task for the instructional designer is to identify the goal of a targeted enterprise along with its component skills and knowledges, and then to design instruction that enables the student to acquire the capability of achieving this integrated outcome. Thus, learners may acquire a fact or a concept that enables them to distinguish a given object or set of objects. Or this fact or concept may be part of a goal that enables them to communicate the stages of some process. Or this fact or concept may be part of a goal that enables them to predict the next stage in a process, to invent a new device, or discover a new process. Each of these is a different enterprise, and each is accordingly represented by a different integrated goal. Each such enterprise requires a different kind of integration of the multiple objectives that support it.

The notion of integrated learning objectives as goals for enterprises implies that this conceptual focus should be given full consideration in instructional design. In addition to the individual capabilities, which result from learning a multiple-objective lesson, provision should also be made for a cognitive representation of the enterprise to which these objectives are related. We propose that different *integrated goals* of various enterprises are represented in memory as different kinds of cognitive structures. Some would call these structures frames (Minsky, 1986) while others would call them *mental models* (Gentner & Stevens, 1983). The notion of *schema* (Rumelhart & Norman, 1978) refers to a cognitive structure that contains blanks or slots to be filled in, as in an application form. Brewer (1987) describes schemas as knowledge structures that are composed of previously acquired generic information. In so far as the enterprise schema embodies the idea of learning transfer, the notion of *work model* (Bunderson, Gibbons, Olsen, & Kearsley, 1981) seems appropriate. In our view, each kind of enterprise is represented in memory by a schema that reflects the purpose or goal of the enterprise category, the various knowledges and skills required to engage in the enterprise, and a scenario which indicates when and how each piece of knowledge or skill is required by the enterprise. There are different kinds of enterprise schemas, just as there are different kinds of application forms. Each such schema contains slots to be filled by the details of any specific enterprise.

Integrative goals, then, are the aims of human enterprises that embody and integrate multiple objectives. The general form of schemas representing such goals is diagrammed in Figure 5.1.

As the figure shows, the *enterprise schema* is expected to contain a number of knowledge and skill constituents which become associated in the service of the integrated goal. These include verbal labels, connected-discourse forms of verbal information, intellectual skills, and cognitive strategies. Depending upon the enterprise, motor skills, and attitudes may also be involved. The integrative goal itself is incorporated in the schema as verbal knowledge. An important feature associated with the goal is the enterprise scenario that relates component activities (identifying concepts, carrying out procedures, etc.) to the goal. It is the scenario that provides a basis for the application of the constituent knowledge and skill in the enterprise performance. This entire complex is what is meant by the enterprise schema.

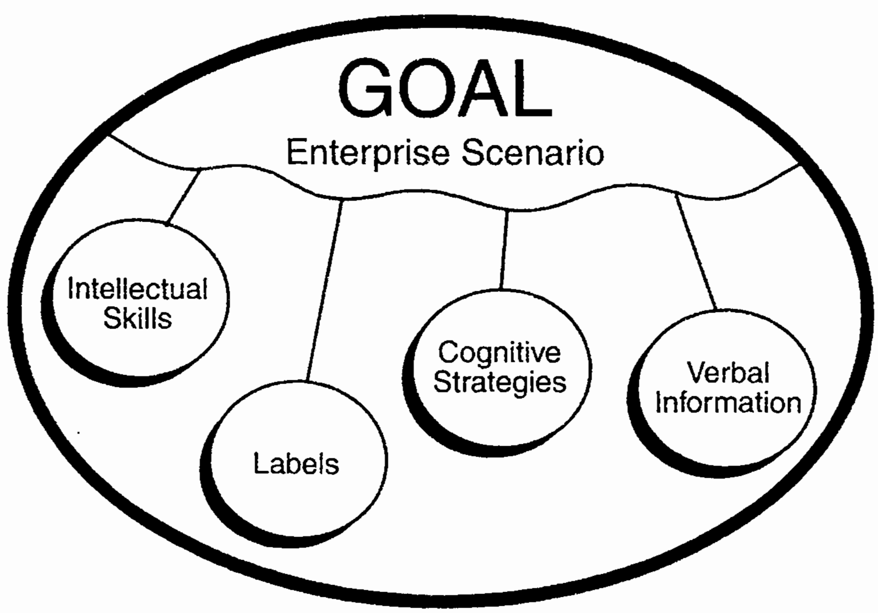

Figure 5.1 The General Form of an Enterprise Schema.

Some related ideas in the writings of other investigators are worthy of note. In a recent paper, Mayer (1989) reviews evidence showing that, in a variety of process activities, students who were presented a mental model (similar to an enterprise schema) performed significantly better than students who were merely taught constituent knowledge and skill about the process. In still another formulation, Elaboration Theory (Reigeluth, 1987), the technique of presenting an epitome resembles that of communicating an enterprise schema to the student. However, an *epitome* is defined as an "overview containing the simplest and most fundamental ideas" (p. 248), and is ambiguous regarding the notion of integrating different kinds of knowledge and skill into a single unified schema.

The instructional designer makes provision for the enterprise goal in instruction by communicating the schema as verbal information. This includes, on the one hand, identification of the intellectual skills and verbal knowledge that relate to the goal, and on the other, the scenario that must be played out in conducting the enterprise. For example, instruction for the enterprise of troubleshooting a piece of complex electrical equipment would normally require conveying information about the current flow in the system as a whole, the identification of functioning (or malfunctioning) parts, and the procedure for checking each of those parts. Problem-solving strategies relevant to troubleshooting represent another type of objective to be included. These individual knowledges and skills would become a part of the scenario that expresses the sequence and purpose of troubleshooting as checking the fault symptom, finding a malfunctioning part, and replacing it.

Categories of Integrative Goals

There appear to be several categories of integrative goals that are useful to distinguish as different kinds of enterprise schemas. Three of these will be identified here in terms of their goals. A following section will give an account of the several singular objectives that compose each of these schemas.

Denoting

An entity (thing, place, event) or class of entities may be denoted by giving its name, the class to which it belongs, and the function it serves. The denoting communication may also include identification of the parts of the entity, their locations, and functions. As an example, a hawser is denoted as a large rope (its class) for towing or moving a ship (its function). Denoting may also proceed to indicate parts, such as the hawser bend (used for connecting two hawsers) and a hawser clamp (a device for gripping a hawser). Entities other than objects may be denoted, such as persons, places, or events. Examples might be the U. S. Attorney General, the city of St. Louis, the 1988 baseball World Series. An enterprise of this sort is a part of many human occupations such as teaching, explaining, orienting, counseling, and giving directions.

Manifesting

Actions involving entities as actors or objects may be arranged in a series of steps leading to a particular result. Such a series is called a *process*, and it is this that is the object of a *manifesting* enterprise. Learners must gain knowledge of the steps in the process. A manifesting enterprise consists of making a process evident to other people (e.g., students, co-workers) by indicating its stages and their sequence. Manifesting a process implies going beyond employing a simple verbal communication; it may require the use of pictures or props, as is commonly done in a demonstration. An example of manifesting a process occurs when a student can indicate the stages in the life cycle of an insect and can show how these stages vary under different environmental conditions.

Discovering

The enterprise of discovering reveals (to observers) a previously unknown novel entity or process. Often, entities and the procedures for manipulating them are inventions. One of the most creative types of enterprise involves the capability to design or *discover* a novel entity or procedure. For example, to remove tight covers from jars, a learner might discover the design of an object that grips the cover tightly, making possible its unscrewing from the jar. Alternatively, a learner might discover a procedure that would cause the cover to loosen its grip on the jar by metal expansion. As another example, having knowledge of control mechanisms in mechanical systems, a learner may discover a hypothesis about biological control mechanisms which trigger phases of the life cycle of insects.

Integrative Goals and Single Objective Categories

Integrative goals are represented in enterprise schemas that incorporate multiple objectives. The several different singular objectives described by Gagne (1985) or by Merrill (1987) become integrated in one or another enterprise schema. Integrative goals are conceived as incorporating, not as supplanting, the various single types of instructional outcomes (facts, concepts, rules, strategies). Enterprise schemas may be seen as building upon one or more of these learning out-comes, in the sense that the latter are constituent parts of the more complex activity. The various kinds of single objectives embodied in enterprise schemas are shown in Figure 5.1.

Denoting

As an integrative goal, denoting includes the intellectual skills of *concept identification* (for both concrete and defined concepts) and also the verbal information of *labeling*. A concrete concept is said to have been learned when the learner can point to an instance of the concept and can distinguish an instance from non-instance. The operation of "pointing," however, may be accomplished by stating a name or label, when it can be assumed that his is firmly associated with the concept. Since the integrative goal of denoting includes communicating to others, both the label and the concept itself must be known and exhibited in the learner's performance. When defined concepts are involved in denoting an entity, the learner gives evidence of attainment by demonstrating the component concepts of the definition and their relationships. This may mean showing the use of a procedure described by the definition: for example, a circle is "the locus of points equidistant from a given point." In communicating such a concept to others, the learner must first know and communicate the definition in verbal form. Thus, denoting a defined concept means demonstrating the relationships of the component concepts in the definition while naming them.

Notice, however, that denoting does not mean simply stating the definition; the latter would be the case if the goal were the single objective of stating verbal information. We realize that the denoting of a defined concept is sometimes tested in practice by requiring the learner to "state the definition." Although such a procedure is often impelled by considerations of convenience and expense, it is one that puts validity at risk. The intention of testing should be to assess the enterprise of denoting, whereas mere verbal knowledge of a definition should be avoided.

Manifesting

Making a sequence of events or a process evident to other people by "showing" constitutes the enterprise called manifesting. A procedure known to the individual may be shown to others, using verbal labels to identify key points in the performance. Or, the learner may describe a procedure that exists externally, as opposed to one that is executed personally. The sequence of stages engaged in by a leaf as it changes color in autumn has the form of a procedure. Since it is what a person observes, rather than does, it is called a process. Showing the process typically involves more than a verbal description. Often it requires picturing, diagramming, and demonstrating. The several single objectives comprising this enterprise include the intellectual skill of following a procedure and the constituent skills of identifying the concepts of leaf structure.

Discovering

The integrative goal of discovering requires problem solving in which the learner finds, in a cognitive sense, a novel process. A botanist, for example, may discover a new way of explaining the changing color of leaves. This problem-solving activity requires that the learner have available some constituent learnings (Gagne, 1985), including particularly those concepts and rules involved in the process of color change. In addition, one or more cognitive strategies of problem solving applicable to botanical structure might be included in the schema.

Discovering often implies relating familiar entities to the goal of an enterprise in new ways. For example, when confronted with Maier's (1931) two-string problem, some subjects were able to use a pair of pliers as a weight, thus enabling a string to be swung as a pendulum so that it could be caught by a person standing in a particular position. Solving such a problem evidently requires an enterprise schema that includes knowledge of strings, of pliers and their weight, of the characteristics of pendulums, and of some rules of pendulum motion. Stated in general terms, the discovering schema includes a number of intellectual skills (concepts, rules), as well as verbal scenarios relating familiar entities to the goal of the enterprise.

The Enterprise Scenario in Learning Transfer

Verbal information in the form of an enterprise scenario is typically a prominent part of an enterprise schema (Figure 5.1). It is this declarative knowledge that relates particular singular objectives that compose the expected behavior to the purposive activity that is the enterprise. The enterprise scenario "tells" the learners that the concept they are identifying, or the procedure they are following, is actually an essential part of a purposeful enterprise. For example, an enterprise scenario may remind students of arithmetic that they are going to encounter future situations requiring them to perform mental subtraction in order to verify the change from a purchase made with a paper-money bill of fixed value. Or, an enterprise scenario may help a student of physics to bring to mind the relation between the practice of electric heating and the cost of electric power. The enterprise schema is likely to be a factor of considerable prominence in the mediation of transfer of learning from one task to another, or from a learning task to a later performance. A number of recent articles on transfer have made a similar suggestion (Brooks & Dansereau, 1987; Gick & Holyoak, 1987; Gray & Orasanu, 1987). As contrasted with factors pertaining to the quality of learning content such as amount and variety of practice, the enterprise frame is a metacognitive feature. The implication it carries for instructional design, therefore, is this: To ensure transfer from training to the job, provision must be made for learner acquisition of an enterprise schema in addition to the specific knowledges and skills that the performance requires. The enterprise scenario of this schema is one that relates each component of knowledge and skill to the goal, and thus to the enterprise that embodies this goal.

Discussion

We perceive a requirement for instructional design to provide for the integration of multiple objectives as they occur in lessons and courses. In addition to the various single objectives described by Gagné (1985) and by Merrill (1987), design theory should encompass instruction in *integrative goals*. Such goals do not supplant single objectives such as labels, facts, concepts, and rules; rather, they incorporate them.

We propose that integrative goals are represented in cognitive space by *enterprise schemas* whose focal integrating concept is the integrative goal. Associated with the integrative goal is an enterprise scenario and the various items of verbal knowledge, intellectual skills, and cognitive strategies that must be learned in order to support the required performances. These performances are brought together in a purposeful activity known as enterprise. Examples of enterprises are: operating X equipment, teaching a science topic, counseling someone about applying for a job, giving directions about how to use a weedcutter. The schema representing the goal of the enterprise and including the goal-related knowledges and skills is an enterprise schema.

Instructional design must specify the conditions for acquisition of an enterprise schema. Besides constituent knowledges and skills, this schema includes a scenario of declarative knowledge relating these skills to the goal. This scenario serves to remind the learner of the purpose for learning the various facts and skills—the relations they have with the enterprise to be accomplished. In view of these characteristics, the enterprise schema is seen as a factor of substantial positive influence in transfer of training.

We anticipate that a learning requirements analysis which focuses on enterprises will also lead to significant changes in the design of instructional strategies. Whereas current instructional design methodology focuses on components such as generalities and examples, which are geared for promoting acquisition of single objectives such as concepts or procedures, a consideration of enterprises as integrated wholes may lead to a future focus on more holistic student interactions or "transactions" (see Merrill, Li, & Jones, 1990a, 1990b). The development of instructional strategy implications of integrated goal enterprises is not further pursued within the present paper.

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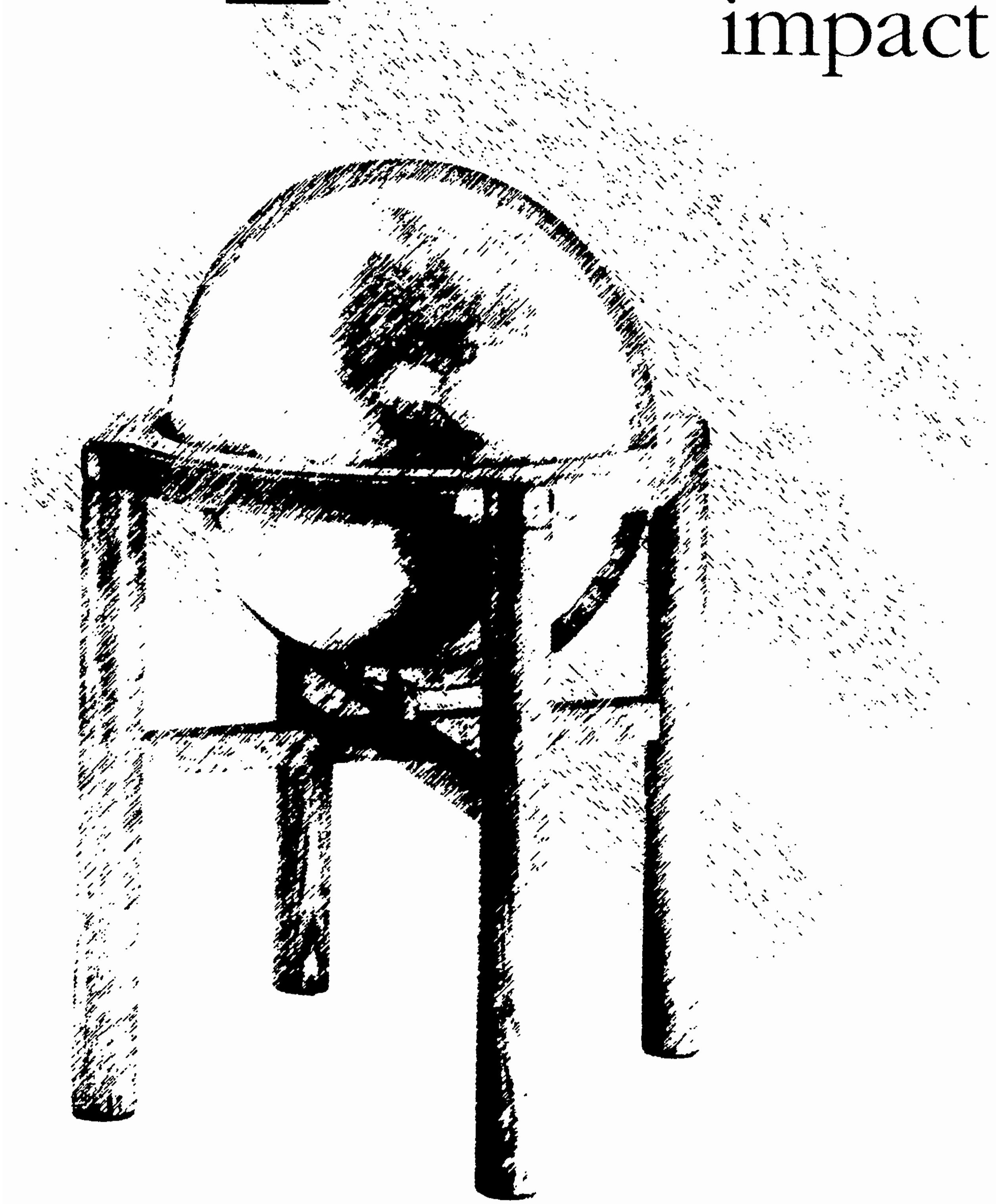
section 2

the impact



This section consists of four analytical discussions of the impact of Gagné's work in a variety of arenas. Gagné's career (as described in the Preface and Appendix A) was eclectic—encompassing research, teaching, administration, and the practice of instructional design. His work pertained to the general study of human learning, military research and training, the education of children, workplace education and training, as well as higher education. Consequently, not only the length of his career (more than 50 years) but the diversity of his work enables him to have a potentially enormous impact. The discussions here relate to his impact on instructional theory, instructional design practice, military research and development, and on design using the new technologies. They highlight his work as both a basic and applied researcher.

Smith and Ragan give a comprehensive description not only of Gagné's contributions, but the pre-Gagné status of instructional theory. They describe the development of his theory over time and then analyze its influence on current instructional design procedural models as well as curriculum development processes. Smith and Ragan emphasize the scholarly integrity of Gagné's work as a key reason for its influential role.

Fields, on the other hand, looks at the interface between Gagné's theory and practice—school curriculum development, instructional design, and efforts to promote transfer of training in a variety of settings. In addition to Gagné's research efforts, Fields recounts Gagné's large-scale curriculum project, *Science: A Process Approach*, and describes its impact on school curriculum practice. This chapter emphasizes the propensity of Gagné's work to fundamentally address practical problems.

In Chapter Eight, Spector summarizes Gagné's work in the military at various times throughout his 50-year career. This discussion encompasses Gagné's stints in Air Force research laboratories and specifically, his work on the Guided Approach to Instructional Design Advising (GAIDA). This chapter gives readers an understanding of Gagné's personality, since it is laced with stories of Spector's interaction with Gagné on a personal level.

Finally, in Chapter Nine, Nelson examines the relationship between Gagné's theory and the design of technology-based instruction. He discusses not only hardware and software issues, but also the knowledge sources and practice of instructional designers. This chapter includes analyses of design models used for computer-based instruction, automated design tools, hypermedia, and intelligent tutoring systems.

Chapter 6

The Impact of R.M. Gagné's Work on Instructional Theory

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Although it is not unusual for R.M. Gagné's work to be considered in a volume addressing learning theories, his contributions can most appropriately be considered as an "instructional theory." An instructional theory is an integrated set of principles, based upon learning theory, other relevant theories, and sound replicable research, that permits one to predict the effects of specific instructional conditions on a learner's cognitive processing and the resulting learned capabilities. Gagné (1985) described the nature of an instructional theory as an "attempt to relate the external Events of Instruction to the outcomes of learning by showing how these events lead to appropriate support or enhancement of internal learning processes. . . The province of an instructional theory is to propose a rationally based relationship between instructional events, their effects on learning processes, and the learning outcomes that are produced as a result of these processes" (p. 244).

How does instructional theory relate to learning theory, instructional psychology, and instructional design models? In contrast to instructional theories that tend to be predictive and prescriptive, learning theories are typically descriptive and explanatory. According to Driscoll (1994) a learning theory is "a set of constructs linking observed changes in performance with what is thought to bring about those changes" (p. 9). Instructional psychology is the study of the facilitation of human learning through instruction and can result in instructional design theories and models. Instructional design models employ instructional theories to prescribe types and levels of instructional support to optimize the achievement of identified learning goals.

Snow and Swanson (1992) suggested that the components of an instructional theory are: "(a) description of desired end states or goals of instruction in a domain; (b) description of goal-relevant initial states of learners prior to instruction; (c) explication of the transition processes from initial to desired states; (d) specification of instructional conditions that promote this transition; (e) assessment of performance and instructional effects" (p. 584). If we compare Gagné's instructional theory to this description, we find that Gagné's theory does have these components. For example, Gagné describes potential *end goal states* in his categorization of learning capabilities. These goal states are generic in that they can apply across a variety of content areas. For each of the goal types Gagné described *goal-relevant initial states*, prerequisite relationship of intellectual skills and relationships of other types of learning. Gagné interpreted information processing theory to explicate the *transition processes* from initial to goal states for each type of learning. Gagné's greatest impact on instructional theory may be his thoroughness in specifying *instructional conditions* to support this transition process. He described these instructional conditions both as generalized events of instruction and as specific conditions of learning for each type of learning capability (*Conditions of Learning*, 1965, 1970, 1977, 1985). Finally, Gagné and his colleagues extended his thorough explication of learning outcomes into recommendations for *assessment* within each category (Gagné & Beard, 1978; Gagné, Briggs, & Wager, 1992).

Although Gagné was the first theorist to bring these elements together into an instructional theory, as with all learning/instructional theorists, his work was strongly influenced by theorists who preceded him. Consequently, to gain an adequate perspective of Gagné's influence on instructional theory, we must first survey the status of instructional theory prior to Gagné's influence.

Status of Instructional Theory Before Gagné

The need for instructional theory has long been recognized, and as early as 1899, William James pointed out that, as important as psychology is to education, it is not something from which the nature of the instruction may be directly induced: "You make a great, a very great mistake, if you think that psychology, being a science of the mind's laws, is something from which you can deduce definite programs and schemes and methods of instruction for immediate schoolroom use" (James, 1899/1958, p. 23). Instructional theory remained an elusive topic before Gagné's contributions of the early 1960s. Two primary avenues of thought regarding instructional theory in the decade or so prior to Gagné's major contributions were a focus on: (a) sequence and content concerns from within a curriculum theory frame of reference; and (b) application of learning theory, particularly applications within a programmed instruction frame of reference.

Curriculum Theory

Much work that characterizes the status of instructional theory before Gagné is seen in the work of curriculum theorists. People such as Bruner and Tyler are among those whose work concentrated on matters of sequence and the content of learning. Bruner's (1960) concept of the spiral curriculum and Tyler's conception of the "rationale" for a course as its design beginning point (1950) are examples of curriculum thinkers' contributions to instructional thinking.

Historically, the persistent pattern in curriculum thinkers' approaches to instruction is to place primary emphasis upon teaching. Hosford (1973), for example, defined curriculum, instruction, and teaching much as an instructional systems specialist or instructional technologist might, but he insisted on placing teaching at the center of his conception of instruction and, in subsequent treatment of a theory of instruction, made the continued assumption that teaching and teachers would be the primary (or only) means of implementation. Such a focus on teaching, it appears, prevented some curriculum theorists from thinking vigorously and directly about instruction itself. Nonetheless, for better or worse, the more philosophical contributions from curriculum thinkers formed a substantial proportion of instructional theory.

Bruner's widely recognized work in instructional theory (1968) proposed four criteria that an instructional theory should meet. An adequate theory of instruction, according to Bruner, would provide the basis for specification of: (a) experiences which will induce motivation to learn, (b) optimal structures of knowledge for learning, (c) optimal sequences of encounter; and (d) the nature and pacing of rewards and punishments. In many regards Bruner's widely heralded work seems now naive and quaint. His concentration on structures of knowledge within disciplines reflects a teaching-centered view of instruction. This structure of knowledge approach groups the "treatment of form of encounter" and "treatment of intrinsic motivation" within a category labeled "rewards and punishments."

Before Gagné's work had become widely recognized (and, of course, remaining conventional in many education specialties today) many authorities believed that the most important instructional considerations lay within the structures of subject matter disciplines, and with the interface between those structures and the broad developmental characteristics of learners. The structures of knowledge within the various disciplines—such as science, mathematics, or history—were (and are) seen to vary radically from discipline to discipline in conceptual, syntactical, and substantive ways (Ford & Pugno, 1964; Phi Delta Kappa, 1964). Gagné brought scholarship to questions of learning from instruction that arise from the psychological requirements of learning tasks, as opposed to questions which arise from parent disciplines from which subject matter comes. Therefore, Gagné's influence yielded prescriptive principles which—though not universally adopted in educational theory—have had a substantial impact upon the theory and research that examines educational practice.

In a less widely recognized but at least equally valuable work that was contemporary to Bruner's, Gordon (1968) presented a relatively mature view of instruction and instructional theory. Gordon defined a theory of instruction as "a set of statements, based on replicable research, which would permit one to predict how particular changes in the educational environment (classroom setting) would affect pupil learning" (p. 3). Gordon differentiated the terms "instruction" and "teaching" by noting that teaching "refers primarily to the human interaction between teacher and pupil" (p. 3) and instruction as the more encompassing term, referring to "the activity which takes place during instruction and within the classroom setting. The term includes both material and human variables" (p. 3). The distinctions that Gordon made between instruction and teaching are useful ones, as the study of instruction and the study of teaching are reflected as separate bodies of literature as well as distinct traditions of interest and inquiry. However, reflecting the curriculum and teaching methods orientation, Gordon restricted his conception of instruction to classroom activities, a restriction that might be viewed as limiting by current instructional theorists.

Applied Learning Theory

Although typically involving itself with animal conditioning experiments, the mainstreams of learning psychology in the first half of the twentieth century, exemplified by Guthrie, Skinner, and Hull, were deeply concerned with human learning. Guthrie's association-centered theory (Guthrie, 1935, 1942) gave rise to Sheffield's (1961) work in learning complex sequential tasks and Lumsdaine's (1961) training research on effects of cueing. Skinner's operant conditioning saw application by Skinner (1954) and Holland (1960). Hull's detailed, systematic, and quantified approach to learning based on drive-reduction led to instructionally relevant research on feedback by Miller and Dollard (1941).

Clearly, learning theory was in disarray when Hilgard wrote the concluding chapter to *Theories of Learning* (Hilgard, 1948): "We need a more careful delineation of the kinds of learning which take place... This search for the appropriate concepts is not merely an exercise in definition or classification. It requires a high order of theory construction, based on open-minded acceptance of demonstrable relationships" (p. 326–327). Almost 30 years later, the concluding chapter in the fourth edition of that work (Hilgard & Bower, 1978) was entitled "Instructional Theory." The first reference cited in that chapter is the first review of instructional psychology in *Annual Reviews* by Gagné and Rohwer (1969). Hilgard and Bower described Gagné's work to that time as one of three models that provide "indications of what is to come" (1978, p. 614). In addition to Gagné's "hierarchical theory," Bruner's "cognitive-developmental theory" and Atkinson's "decision-theoretic analysis for optimizing learning" are described. Of these, although all three did important subsequent work, Gagné appears to have gone the furthest toward development of a full instructional theory.

A great deal of interest in the 1950's was generated by the innovation called "programmed instruction." Embodied in both teaching-machine and text-based forms, programmed instruction carried with it ideas of far greater importance than the competing specific forms and rules dictating format that were matters of heated debate at the time. With programmed instruction, an agency other than a person was seen as an instrument of instruction. Previously, all non-human tools including books, television, and the various forms of audiovisual media, were conceptualized as aids or resources for a teacher's use. Even the powerful medium of motion pictures (and later television) was viewed as something that had "classroom" uses, which required a teacher's introduction and follow-up for meaningful learning to anticipated.

This radical change in view of the potential of instructional media brought with it a radical change in what might be studied as "instruction" and how research on it might be conducted. In his landmark review, "Instruments and Media of Instruction," Lumsdaine (1963) pointed out the significance of the ideas behind programmed instruction for thinking about research on instruction: "...the control of learner behavior and feedback which is provided by the continuous record of student response from auto-instructional programs may afford the most promising vehicle yet developed for the analytic experimental study of variables affecting human learning (as well as for the incorporation of research findings in improved instruments)" (Lumsdaine, 1963, p. 608). Research on programmed instruction brought with it, perhaps unknowingly but certainly inevitably, focused concern on matters of *form of encounter* with material to be learned outside the frame of reference of "teaching." As teaching itself is not a reproducible event, the study of teaching has focused on matters that can be of ultimate utility in understanding the role of teachers, understanding the teaching act, and understanding interactions among teachers, learners, and activities. When studying instruction-using agencies providing sequenced and reproducible events, controlled investigations of *form of encounter* became practicable. An enormous corpus of research was developed during the 1950s and 1960s under the programmed instruction umbrella in areas such as practice, feedback, sequence, and criterion-referenced assessment.

One example of how work in programmed instruction contributed to instructional theory can be seen in "validation" procedures for programmed instruction. The first work in what would now be labeled "formative evaluation" was developed under the notion of "how should programmed instruction be validated?" Procedures for the development and establishment of known quality in programmed instruction materials have evolved over the years to include instruction in any form and are the basis of current formative evaluation principles and procedures. Other examples can be seen in studies on such areas as instructional feedback, instructional event sequencing, pacing, optimal prompting of practice, and forms of practice and response.

Other cornerstones of contemporary instructional design have their roots in programmed instruction. However, the generalizations which transpired from notions of "how to best implement a particular programmed instruction format" on the one hand into "how to optimally conduct instruction" on the other, are not trivial. Gradually attention began to shift from the procedural details to variables, questions, and models of instruction that would underlie the techniques. No one contributed more to this shift in thinking—much of his own work in the 1950s and early 1960s can be seen as an embodiment of it—than Robert Gagné.

Precursors to Instructional Theory

Of the schools of thought that underlie instructional theory, Gagné clearly comes from the "applied science" perspective. As a psychologist, he studied learning in demanding, realistic settings, and was, in fact, somewhat impatient with colleagues whose purity of purpose prevented their doing the messier and often less clear applied research that instructional theory building requires. In a review of factors that contribute to learning efficiency for a volume on programmed instruction sponsored by the Air Force Office of Scientific Research, Gagné and Bolles noted that "the learning tasks that have been most intensively studied by psychologists have been of an artificial "laboratory" variety; relatively little is known about learning in real life situations" (Gagné & Bolles, 1959, pp. 13–14).

Training research in the 1950s put Gagné in touch with a wide range of instructional problems, representing a variety of learning tasks. Illustrative studies in the literature are Gagné (1954) "An Analysis of Two Problem Solving Activities" involving troubleshooting and interpretation of aerial photographs, and Gagné, Baker, & Wylie (1951) "Effects of an Interfering Task on the Learning of a Complex Motor Skill" involving manipulations of controls similar to aircraft controls. In a review of problem-solving and thinking, Gagné pointed out the relevance of trouble shooting studies to issues in concept formation (Gagné, 1959). Wide and vigorous participation in research on learning and instruction in the military environment, along with his thorough and rigorous background as a learning psychologist, may have created the dissonance that motivated Gagné to develop the concepts of types of learning, learning hierarchies, internal conditions of learning, and events of instruction, including external conditions of learning. In the following pages, we will discuss each of these three contributions to instructional theory.

Instructional Theory Contributions

Gagné developed four major propositions that constitute his instructional theory:

(a) Learning goals can be categorized as to learning outcome or knowledge type (types of learning);
(b) Learning outcomes can be represented in a predictable prerequisite relationship (learning hierarchies);
(c) Acquisition of different outcome categories requires different internal processes (internal conditions of learning);
(d) Acquisition of different outcome categories requires identifiably different instructional processes (events of instruction and external conditions of learning).

Development of Types of Learning

Gagné was, of course, not the first theorist to suggest that all learning is not alike, that learning might be analyzed into different types of learning.

Indeed, as early as 1933 Carr suggested classes of experimental learning tasks and warned that principles that had been derived about one set of tasks could not necessarily be generalized to other classes (Melton, 1964). In the 1940s scientists such as Melton (1941) and Tolman (1949) continued the efforts to categorize learning types. During an informal meeting of college examiners at the 1948 American Psychological Association conference, Bloom and his colleagues discussed the need for a set of common descriptors of learning to facilitate communication among them. This effort resulted in "Bloom's Taxonomy" of cognitive educational objectives (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956) and Krathwohl's taxonomy of affective educational objectives (Krathwohl, Bloom, & Masia, 1964). Despite the original intention of these taxonomies to standardize terminology, they readily assumed the stature of psychologically-based correlates.

In 1962, Melton organized a "Symposium on the Psychology of Human Learning" that was held at the University of Michigan in Ann Arbor. The focus of the symposium was to discuss "the interrelationship of different categories of human learning" (p. vii). Melton later edited a book *Categories of Human Learning* (1964) that compiled many of the papers from this symposium. Among these was Robert Gagné's chapter "Problem Solving." In this chapter Gagné presented a table entitled "A Suggested Ordering of the Types of Human Learning" in which he proposed the following six types of learning: Response learning, chaining, verbal learning (paired-associates), concept learning, principle learning, problem solving (Gagné, 1964). Gagné did not cite a previous publication related to these concepts, so this chapter may be the first appearance of his "types of learning outcomes" categories. In this chapter he began to differentiate between verbal learning and "nonreproductive" types of learning, such as concept learning and problem solving. This differentiation eventually led to his separate domains of learning of "verbal learning" and "intellectual skills."

Gagné presented the first complete statement of the types of learning conception in his first edition of *The Conditions of Learning* (Gagné, 1965). He began by reviewing learning theory and research, such as James, Dewey, Watson, Thorndike, Tolman, Ebbinghaus, Pavlov, and Köhler, introducing the idea of types of learning with the notion of "learning prototypes:"

> Throughout the period of scientific investigation of learning there has been frequent recourse to certain typical experimental situations to serve as prototypes for learning. . . . These learning prototypes all have a similar history in this respect: each of them started to be a representative of a particular variety of learning situations. Thorndike wanted to study animal association. Pavlov was studying reflexes. Ebbinghaus studied the memorization of verbal lists. Köhler was studying the solving of problems by animals. By some peculiar semantic process, these examples became prototypes of learning, and thus were considered to represent the domain of learning as a whole, or at least in large part (p. 18–19).

Gagné (1965) presented eight types of learning in the first edition, in a rather strict hierarchical relationship. He described all types but the first, signal learning (classical conditioning), as having prerequisite relationships with one another. Gagné carefully referenced researchers that had examined these eight types of learning:

1. Signal Learning (Pavlov, 1927)
2. Stimulus-Response Learning (Thorndike, 1898; Skinner, 1938; Kimble, 1961)
3. Chaining (Skinner, 1938; Gilbert, 1962)
4. Verbal Association (Underwood, 1964)
5. Multiple Discrimination (Postman, 1961)
6. Concept Learning (Kendler, 1964)
7. Principle Learning (Gagné, 1964)
8. Problem Solving (Katona, 1940; Maier, 1930) (pp. 58–59).

This list remained relatively unchanged in the second edition of *Conditions of Learning* (1970). By the third edition (Gagné, 1977), Gagné added information processing theories to the treatment of learning prototypes, recasting the types of learning to some degree by their different cognitive demands. In addition, an increasing influence of task characteristics, rather than psychological processes guided the form and content of the types of learning. In its latest form as of this writing (Fourth Edition, Gagné, 1985), he identified distinctly different categories within the domain of intellectual skills: discriminations, concepts, rules, and higher-order rules (domain-specific problem solving). He proposed that these knowledge types are in a prerequisite, vertical transfer relationship, with discriminations prerequisite to concepts, concepts prerequisite to rules, and rules prerequisite to problem solving. The types of learning in the fourth edition are:

1. Intellectual Skills
   - discriminations
   - concepts
   - rules
   - problem solving
2. Cognitive Strategies
3. Verbal Information
4. Motor Skills
5. Attitudes

(In 1984 Gagné pointed out that the verbal information category could also be termed "declarative knowledge" and the intellectual skills category could be termed "procedural knowledge.")

More recently, Gagné and Merrill (1990) identified another category, which they termed "enterprise" (see Chapter 5). They described this category as being substantively different from the other learning outcomes that Gagné or Merrill had previously identified, requiring the integration of the other more simple learning outcomes, such as rules, concepts, and declarative knowledge.

There are two ways in which one might view these outcomes: as descriptions of *tasks* (with external "task-related" differences) or as descriptions of *learned abilities* (with differences arising out of distinctive processing or memory structures). Gagné has tended to define these outcomes as the latter, describing them as "learned dispositions," "capabilities," or "long term memory states," (1985, p. 245). He described verbal information and intellectual skills as having distinctly different memory storage systems, consistent with those of other theorists, such as Anderson (1990). An empirical basis for the "verbal information" knowledge to be stored as propositional networks is provided by Gagné and White (1978). Rule-using is described by Gagné and White as stored in hierarchical skill structures, which they referred to as "intellectual skills." Verbal information has been described more recently by Gagné (1985) as being stored as propositional networks or schemata. He described rules, including concepts (defining rules), as being stored as "if ... then" productions. The storage of problem solving capabilities themselves was not addressed, although interconnections of schemata and productions were implied. The storage mechanisms of attitudes, motor skills, or cognitive strategies are also not explicitly discussed.

Gagné's categorization of learning outcomes has not been without its critics. Gagné characterized his categorization system as more internally than externally derived. Kyllonen and Schute (1989) criticized this characteristic, describing Gagné's categorization of learning types as a "rational taxonomy," developed via proposing "task categories in terms of characteristics that will foster or inhibit learned performance" (p. 120). They suggested that the limitation of such categories is that their basis is not psychological processes and, therefore, such processes are unsystematically considered.

Development of the Learning Hierarchies Concept

Perhaps as significant as his delineation of categories of learning, is Gagné's conception of a learning hierarchy (see Chapter 2). Although this hierarchical relationship was implied in the taxonomies of a number of theorists (Cotterman, 1959; Demaree, 1961; Lumsdaine, 1960; Miller, 1962; Parker & Downs, 1961; Stolurow, 1964; Willis & Peterson, 1961), it was Gagné who brought the conception of "learning hierarchy" clearly into focus with his statements regarding the nature of these relationships and his research to validate these principles.

Gagné's first references to "learning hierarchies" appears in articles published in 1962, a report of a study, "Factors in Acquiring Knowledge of a Mathematical Task" (Gagné, Mayor, Garstens, & Paradise, 1962) and another study, "The Acquisition of Knowledge," (Gagné, 1962) which involved similar learning tasks. These reports were preceded by Gagné and Paradise's 1961 study, which formed a foundation for the latter studies. In 1961, Gagné and Paradise found support for the proposition that transfer of learning from subordinate sets of learning tasks could account for performance in a terminal learning task. In a subsequent study, Gagné, Mayor, Garstens, and Paradise (1962) sought to extend and confirm the validity of the idea of the "learning hierarchy." In this study, the posttest supplied information about achievement of not only the terminal task (adding integers) but also the 12 prerequisite learning sets, each scored as "pass" or "fail." Success in final task achievement correlated highly with the number of subordinate tasks successfully achieved for both of the two terminal learning tasks (.87 and .88). Patterns of transfer among the subordinate tasks also conformed to theoretical predictions of a learning hierarchy.

In 1973, Gagné fully described learning hierarchies as having the following characteristics. They: (a) describe "successively achievable intellectual skills, each of which is stated as a performance class;" (b) do not include "verbal information, cognitive strategies, motivational factors, or performance sets;" and (c) describe "only those prerequisite skills that must be recalled at the moment of learning" to supply the necessary "internal" component of the total learning situation (p. 21–22).

White (1973) reviewed a number of studies that attempted to validate learning hierarchies developed according to Gagné's principles. He found none that had a perfect match with predicted prerequisite relationships. However, he suggested that many of the studies were seriously flawed by imprecise specification of prerequisite tasks, using only one item per prerequisite task, small sample sizes, and other methodological problems. Research has continued both on methodologies to validate hierarchies and techniques for specifying hierarchies (e.g., Airasian & Bart, 1975; Cotton, Gallagher, & Marshall, 1977; Griffiths, 1983; Kee & White, 1979; Wilson, 1989; Winkles, 1986). For example, Winkles (1986) investigated the learning of trigonometry skills with a learning hierarchy validation study, identifying both lateral and vertical transfer. Two experiments with eighth and ninth grade students involved instructional treatments described as "achievement with understanding" and "achievement only." Results reported "achievement with understanding treatment is better for the development of lateral transfer for most students, and of vertical transfer for the more mathematically able students, whereas the differences between the treatment groups on tests of achievement and retention of taught skills are not significant. A small amount of additional instruction on vertical transfer items produces much better performance under both treatments" (p. 275).

Internal Conditions of Learning

Perhaps more than the explication of categories of learning capabilities or of learning hierarchies, Gagné's major contribution to instructional theory lies in his suggestion that for each category or subcategory of learning capability to be acquired, certain internal conditions *must* be met. His attention to the conditions within the learner has been long lasting, as he has conjectured about necessary conditions within the learner since his first edition of *The Conditions of Learning* (1965). He further suggested from this first edition that these internal conditions vary somewhat by learning capability. Specifically, he has proposed in more recent years that three internal events may differ most across learning capabilities: "(a) substantive type of relevant prior knowledge; (b) manner of encoding into long term storage; (c) requirement for retrieval and transfer to new situations" (1984, p. 514). It should be noted that in Gagné's detailing of the internal conditions of each type of learning, the major internal condition that he details is prerequisite knowledge. Gagné used an information-processing model including processes of attention, selective perception, semantic encoding, retrieval, response organization, control processes, and expectancies to contextualize these cognitive processes. He, therefore, in his 1985 edition of *The Conditions of Learning* pointed out that the events that may differ most significantly from learning category to learning category are those corresponding to these three internal events.

Development of the Events of Instruction and External Conditions of Learning

In 1962, in addition to presenting the "learning hierarchies" concept, Gagné also began to consider features that should be included in the instructional situation, such as description of the required terminal performance and provision of "guidance of thinking." Then, in the first edition of *The Conditions of Learning* (1965) Gagné included a section headed "component functions of the instructional situation" which, except for its label, is basically identical to the "Events of Instruction" seen in later editions of *The Conditions of Learning*. The eight functions were: (a) presenting the stimulus; (b) directing attention and other learner activities; (c) providing a model for terminal performance; (d) furnishing external prompts; (e) guiding the direction of thinking; (f) inducing transfer of knowledge; (g) assessing learning attainments; and (h) providing feedback. In the second edition of *The Conditions of Learning* (Gagné, 1970), Gagné added "The Events of Instruction" to a new chapter titled "The Design of Instruction," completing the development of the fundamental concept of "the Events of Instruction."

Although researchers have expended much effort in investigating the optimal nature of individual events (e.g., feedback research, research on objectives), the validity of the Events of Instruction as a whole have not been subjected to much research. This must in part be due to Gagné's assertion that instruction must not necessarily include all events on all occasions, as learners are often able to supply the processing that the events evoke without external prompting. The authors did, however, find one study that examined the effectiveness of the Events of Instruction for high school students on the use of quotation marks (Coats, 1986). The experimental study involved three treatments: (a) all nine events; (b) only four events: presenting stimulus materials, providing learning guidance, eliciting performance and providing feedback; and (c) the same events as in treatment b with more elaborate eliciting performance and feedback events. The results indicated no main effects for treatments, but an interaction between ability and treatment: High ability learners performed better under treatment b; low ability learners under treatment c. It is really no surprise that by high school the students did not need much introduction to quotation marks, that are represented by the early Events of Instruction. Nor is it a surprise that the low ability learners performed better under a condition that required more practice and feedback.

As an instructional psychologist, Gagné was particularly interested in the external conditions that might occur or could be provided to "activate and support" the internal processing necessary for learning to occur (Gagné, 1985, p. 276). In fact, Gagné defined the purpose of instructional theory as "to propose a rationally based relationship between instructional events, their effects on learning processes, and the learning outcomes that are produced as a result of these processes" (1985, p. 244). Therefore, Gagné derived the external events from the internal events of information processing.

Gagné particularized the general external events, the "Events of Instruction," that begin to be described in his work in 1962 to specific prescriptions for external conditions for each type of learning, event by event, for each of the categories of learned capability. Much of these external conditions is logically derived from the intersection of the function

Table 6.1

Gagné and Glaser's Learning Categories X Conditions Summary: Effective Learning Conditions for Categories of Learned Capabilities

Type of Capability	Learning Conditions
Intellectual Skill	• Retrieval of subordinate (component) skills • Guidance by verbal or other means • Demonstration of application by student; precise feedback • Spaced reviews
Verbal Information	• Retrieval of context of meaningful information • Performance of reconstructing new knowledge; feedback
Cognitive Strategy (Problem Solving)	• Retrieval of relevant rules and concepts • Successive presentation (usually over extended time) of novel problem situations • Demonstration of solution by student
Attitude	• Retrieval of information and intellectual skills relevant to targeted personal actions • Establishment or recall of respect for human model • Reinforcement for personal action either by successful direct experience or vicariously by observation of respected person
Motor Skill	• Retrieval of component motor chains • Establishment or recall of executive sub-routines • Practice of total skill; precise feedback.

Note: From Gagné, R.M. & Glaser, R. (1987). Foundations in Learning Research. In R.M. Gagné (Ed.) Instructional Technology: Foundations (p. 64). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

of the external event (those cognitive processes that it supports) and the nature of the learning capability. He labeled these external supports for each type of learning as their "(external) conditions of learning."

Gagné and Glaser (1987) included an excellent summary of hypothesized differential learning conditions for types of learning.

Unfortunately, there has not been systematic research investigating the validity of the principles for external conditions for specific types of instruction as suggested by Gagné. However, there are some lines of research that have suggested that his underlying premise that different types of learning are facilitated by different instructional conditions. For example, a meta-analysis by Schimmel (1983) suggests that feedback may be more potent for intellectual skill objectives than for verbal information objectives. In addition, Schimmel found that confirmation feedback was more useful than correct answer feedback for verbal information outcomes. However, he did not find this superiority of confirmation feedback for intellectual skills objectives. Research on the value of providing learners with objectives reveals another example of research that may support Gagné's principles of conditions of learning. Hartley and Davies (1976) found that providing objectives benefited students when the learning task is an intellectual skill, but were not significantly beneficial to promote verbal information learning. Although these findings are in no way comprehensive, they do provide some validation of an outcome by conditions theory of instruction.

The Relationship of Gagné's Work to Learning Theory

Gagné's work is not easily related to a single learning theory base. His early work, frequently characterized as behaviorist, might better be considered more broadly as associationist. (Associationists, often early verbal learning theorists, study how ideas became associated through experience.) Within the associationist tradition, his work appears to fit better within the functionalist group, who studied mental processes required for associations, rather than either connectionist, who studied the connections between sense impressions and responses, or the behaviorists, who studied how to strengthen these connections through reinforcement (Bower & Hilgard, 1981; Wilson, 1980).

The integrative nature of his work, particularly as reflected in the first edition of *The Conditions of Learning*, transcended the traditional categories of learning theory. An examination of the sources for the eight categories of learning identified in this first edition reveals origins in field theory (from Gestalt psychology) as well as functionalism and behaviorism. The range of learning types that he wished to consider were not adequately examined under any single theory at that time, so he had to examine a number of learning theories in order to develop his instructional theory.

Certainly, by the first edition of *The Conditions of Learning* (1965), Gagné was beginning to conjecture about the internal conditions of the learner. And, by the second edition, he used an information processing model (although it was not labeled as such) to describe the cognitive processes that occur during a "learning sequence" (1970, pp. 70–71). In the third edition of *The Conditions of Learning* (1977), Gagné's instructional theory was thoroughly integrated with information processing theory. Although he employed other theories, as appropriate, Gagné has continued to draw substantially from information processing theory, one of the family of cognitive learning theories, as his basis for describing the internal processes and structures of learning that are affected by the external conditions and Events of Instruction.

It is difficult to utilize a single learning theory with which to characterize Gagné's work. An attribute of Gagné's theory that makes it so difficult to accurately categorize is that although his theory base was eclectic in *source* it was unified in *result*. Hilgard and Bower pointed out that Gagné's work "is not strictly an eclectic theory (which chooses good principles from here and there without any order among them), but is the beginning of a unified theory" (1966, p. 569). And that result, an instructional theory, even in its earliest versions is not well classified as behaviorist or even associationist psychology. Gagné's theory as reflected in later editions of *The Conditions of Learning* moved even further from the associationist perspective and became increasingly based on cognitive psychology, with an information processing emphasis. Perhaps the source of the difficulty in classifying Gagné's theory arises from attempts to classify it under the categorization system of learning theories, when it is in effect an instructional theory that proposes facilitating instructional conditions for a range of learning types from declarative knowledge to psychomotor skills to attitudes. No single learning theory at this time appears to adequately explain or predict all of these types of learning. Hence, an eclectic learning theory base for Gagné's instructional theory is entirely appropriate.

Influences of Gagné's Theory on Instructional Design Models

Gagné's theory has been foundational in providing the basis of what can be termed "conditions-based" models of instructional design. Conditions-based models are predicated upon the propositions that (a) learning can be classified into categories that require similar cognitive processes for learning ("internal conditions of learning") and, therefore, (b) within these categories of learning similar instructional supports are needed to facilitate learning ("external conditions of learning") (Ragan & Smith, 1996). Conditions-based models of design which are derivative of Gagné's work include those by Merrill (1983), Reigeluth (1979), Merrill, Li, and Jones (1990a & 1990b), and Smith and Ragan (1999). We will briefly describe these models below.

In the early 1970s, M.D. Merrill developed a conditions-based model for instructional design called "component display theory." Merrill noted that component display theory evolved from his interactions with students studying Gagné and that "CDT is founded on the same assumption as Gagné's work—namely that there are different categories of outcomes and that each of these categories requires a different procedure for assessing achievement and a different procedure for promoting the capability represented by the category" (Merrill, 1983, p. 284–285). Early work describing most of the elements of CDT appears in Merrill and Boutwell (1973). CDT classifies objectives in a two-dimensional matrix made up of three performance levels and four content types. This 12-category system differs from Gagné's in that instead of having a declarative knowledge category, as Gagné does, which would include remembering facts, concept definitions, rule statements, and procedural steps, CDT provides separate categories for each of these types of declarative knowledge. And, instead of having a single category for cognitive strategies, as Gagné does, CDT proposes "find" operations for each of the content types: Find a fact, find a concept, find a rule, and find a procedure. CDT also includes a treatment of external conditions for learning as "presentation forms," including content (generality or instance), and approach (expository or inquisitory) as primary forms and, for secondary presentation forms, elaborations such as context, prerequisite, mnemonic, mathemagenic help, representation or alternative representation, and feedback. The idea of presentation forms relating to different categories of learning appears to be an elaboration of Gagné's conceptions of external conditions for learning.

Pinning down differences and similarities between Merrill's CDT and Gagné's types of learning is a matter of describing moving targets because both systems have changed over the years. For example, Gagné's "types of learning" evolved into a very different form from that which was presented in 1965. In general, the types of learning evolved to keep up with changing knowledge about learning and cognition as well as different ideas about learning from instruction which were being developed by contemporaries. We can speculate that Merrill's component-display theory may have provided some of the impetus for change in Gagné's types of learning during the 1970s.

C.M. Reigeluth developed a model for instructional design, the "elaboration theory," during the late 1970s (Reigeluth, 1979). As an extension of Merrill's component display theory, elaboration theory may be seen as a "grandchild" of Gagné's seminal work. Elaboration theory takes a broader view than CDT and provides guidance for the design of instruction for complex, unfamiliar, multi-topic content rather than prescribing the form of encounter for individual lessons. The conditions-based nature of the model is seen in Reigeluth's specification of three differing structures, conceptual, procedural, or theoretical, which are selected based upon the goals of the course. Later development by Reigeluth includes the "simplifying conditions model" which retains a conditions-based orientation by suggesting that different simplifying conditions structures need to be developed for each of the kinds of knowledge structures described (Reigeluth & Rogers, 1980; Reigeluth, 1992).

In part an extension of CDT, Merrill and associates have formulated a model for instructional design, which also has links to Gagné's work. This new design model is entitled "ID^2"—a "second-generation" instructional design model (Merrill, Li, & Jones, 1990a, 1990b). In large measure, ID^2 was developed to assist in the development of an expert system for instructional design, "ID Expert." ID^2 vigorously extends the basic conditions model, making more explicit the theorized relationship between learning outcomes and internal/external conditions of learning:

a) A given learned performance results from a given organized and elaborated cognitive structure, which we will call a mental model. Different learning outcomes require different types of mental models;
b) The construction of a mental model by a learner is facilitated by instruction that explicitly organizes and elaborates the knowledge being taught, during the instruction;
c) There are different organizations and elaborations of knowledge required to promote different learning outcomes (Merrill, Li, & Jones, 1990b, p. 8).

Smith and Ragan (1999) developed an approach to the design of instruction that exemplifies and elaborates Gagné's theory. Using Gagné's types of learning, they postulated a generalized cognitive process necessary for the acquisition of each of the different learning capabilities, thereby deriving a system of instructional strategy recommendations for different types of learning. Smith and Ragan also suggested that the Events of Instruction as Gagné portrayed them insufficiently considered learner-generated and learner-initiated learning, and restated the events so that they could readily be perceived as either learner-supplied, in the form of learning strategies, or instruction-supported, in the form of instructional strategies.

Smith and Ragan (1999) have proposed a model—Comparison of Generative/Supplantive Strategy (COGSS)—for determining the balance between instructional strategies (instruction-supplied events) and learning strategies (learner-supplied events) based upon context, learner, and task variables. They also proposed that there is a "middle ground" between instruction supplied, supplantive (also known as "mathemagenic") events and learner-initiated events, in which the instruction facilitates or prompts the learner to provide the cognitive processing necessary to an instructional event.

Gagné's instructional theory has spawned at least two generations of instructional design theories that have concretized, elaborated, and exemplified Gagné's conditions-based propositions. However, his influence

* The propensity to cite "intellectually dated" rather than available and more recent work that would more accurately represent the current development of Gagné's theory is distressingly common in not just the curriculum theory literature, but in many sources that cite his work. Another example of such a problem is found in Bower and Hilgard's learning theory text (1981), which states that Gagné is (note present tense) an associationist and cites a 1970 edition of *Conditions of Learning*. In some cases these statements and dated citations may be results of simple oversights or sloppy scholarship. In other cases they appear to be intentional in order to misrepresent Gagné's work and position. Such distortions are reprehensible and violate the very core of what constitutes "good scholarship." These misrepresentations are made all the more unjust by their targeting the work of a scholar who has for many been the very personification of a "life-long scholar." His work has developed continually throughout his professional life as he examined his position and responded with thoughtful revisions of his ideas. He has also been meticulous in *his* citation of the work of others. In addition, such misrepresentation has created no end of difficulty for those in our field, as communication with colleagues and students who have read such misrepresentations can be difficult, time-consuming, and even embarrassing to some who are involved.

has extended beyond instructional design theory into other areas of educational design, including curriculum design.

Influences of Gagné's Theory on Curriculum Design

Although Gagné's work was directed at the study of instruction, not at teaching or curriculum, a substantial influence from his ideas can be observed in those fields. Sometimes harboring conceptions fundamentally hostile to ideas grounded in learning theory, the curriculum and teaching methods traditions represent a "tough audience" for Gagné. However, as early as 1966 W.B. Ragan, a curriculum theorist whose *Modern Elementary Curriculum* was an influential text for more than 25 years, made extensive use of Gagné's ideas in its explanation of learning. A survey of more recent curriculum texts found some evidence of the impact of Gagné's ideas, such as the importance of consideration of types of learning when determining an instructional approach. For example, Pratt (1980) prescribed the matching of instruction with objectives, classifying objectives as knowledge, skills, physical development, dispositions, and experiences. With the exception of "experiences," Pratt's categories of objectives are a close fit to Gagné's types of learning. Indeed, in Pratt's chapter describing these objective categories, he cited Gagné and provided information on intellectual skills from Gagné and Briggs (1979). The basic approach that Pratt recommended, deriving plans for the form of instruction from (among other sources) the different demands placed on learners in achieving different sorts of objectives, is a solid application of Gagné's thinking.

Posner and Rudnitsky (1994) proposed a learning task categorization scheme very similar to Gagné's: Employing understandings (cognitive and affective), and skills (cognitive skills, psychomotor-perceptual skills, and affective skills). They cited Gagné as one of the sources of their categorization scheme. In another text, Robinson, Ross, and White (1985) identified different "growth schemes" for different types of learning: inquiry skills, knowledge outcomes, and affective outcomes. This idea of tying different educational experiences to different types of learning is very much in the Gagné tradition.

Too often, unfortunately, curriculum theorists badly misinterpret Gagné's ideas or represent early work as if it reflects his current thinking. In citing a 1967 definition of curriculum offered by Gagné, Tanner and Tanner (1980) noted that Gagné's definition "assumes that learning is mechanical and linear, and that the learner is a mere mechanism to be conditioned toward making the right automatic responses" (p. 26). The quote to which Tanner and Tanner are responding, is within a discussion of cumulative learning effect from mastery of prerequisite learning, "curriculum is a sequence of content units arranged in such a way that the learning of each unit may be accomplished as a single act, provided that the capabilities described a specified prior units (in the sequence) have already been mastered by the learner" (Gagné, 1967, p. 23). Perhaps in retribution for such a simplistic definition of curriculum, Tanner and Tanner provided a characterization of Gagné's approach as being based on conditioning and "right responses." This interpretation is totally inaccurate. In addition, it is dismaying that in writing a 1980 text that the authors chose to refer to a 1967 publication of Gagné's work, rather than to the most recent edition of *The Conditions of Learning* (1977) that would have more accurately reflected Gagné's position at the time.[8]

Conclusion

As described in the discussions of Gagné's major theoretical contributions, Gagné has developed, refined, and extended his theory over time. This continuing development based upon new theory and research distinguishes him among scholars in educational/instructional psychology. His instructional theory fulfills many of Snow and Swanson's (1992) criteria that were presented at the beginning of this chapter as components of an instructional theory:

a) Description of desired end states or goals of instruction—Gagné's types of learning
b) Description of goal-relevant initial learner states—Gagné's prerequisite analysis via learning hierarchies
c) Description of the transition processes—Gagné's internal conditions of learning
d) Detailing of instructional conditions that promote this transition—Gagné's events of instruction and external conditions of learning.

Gagné has left some questions for future researchers and theorists to work out. One of these areas is in the description of the transition processes between novice and expert. Gagné has carefully defined some of these internal conditions, particularly prerequisite knowledge states. It is left to others (such as Champagne, Klopfer, & Gunstone's (1982) work on design of physics instruction) to delineate these processes more completely for the various learning types through careful empirical validation. A second area is the clear explication of the relationships between required internal processes and external conditions of learning. Within this study may be the examination of necessary versus sufficient conditions to support internal processing. A third area of extension might be a further examination of the relationship between declarative knowledge and intellectual skills. There appears to be ample evidence to support the conclusion that the ability to state the generalities underlying intellectual skills is not prerequisite to the learning of intellectual skills. However, it is still unclear whether some other aspect of the declarative nature of intellectual skills might be prerequisite. A test of the robustness of a theory is not only the number of questions it answers, but also the number of questions it spawns. Gagné's instructional theory is fertile with substance to be examined by future scholars.

It is difficult to overestimate the impact R. M. Gagné has had on instructional theory. Although his has not been the only important voice in shaping the field, it has been an enormously influential one by virtue of the prodigious volume of original work, which is at once bold in its conceptions and careful in scholarship. This combination of thoroughly grounded yet vigorously inventive work has left a legacy upon which a field of study may build.

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Chapter 7

The Impact of Gagné's Theories on Practice

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The relationship between Robert Gagné's theories and research in instruction and learning are discussed in depth in other chapters. The focus of this chapter will be the significant influence of Gagné's theory and research on instructional design practice in a variety of settings. Gagné has had a tremendous influence on the field of instructional design as evidence by the length of his career and his numerous publications. He also has influenced teaching and curriculum development through his research and theory. Gagné used standard practice as a stimulus for the development of theory. Throughout his career, Gagné was always cognizant of the gap between theory and practice, and addressed this gap by directing many of his investigations toward practical problems.

I felt the influence of Robert Gagné during my military training in the late 1950s and early 1960s. These were my earliest experiences as an adult learner and a teacher of adults. Reviewing the Gagné literature for this chapter confirmed a long held suspicion about these military experiences regarding Gagné. There seems not only to be a possibility, but also a high probability, that my training was influenced in no small measure by Gagné and his associates in the military. I experienced first hand the effectiveness of military training based upon Gagné's principles as both a trainer and trainee. However, my interest in Gagné's influence on practice is more than an outgrowth of my military experience. That, in conjunction with 25 years as a practicing instructional designer in public schools, colleges and industry has created a somewhat personal relationship to Gagné and his contributions.

This chapter will explore Gagné's influence on practice by first examining the relationship between theory and practice especially in relation to instructional design, and then discussing curriculum development and transfer of learning.

The Relationship Between Theory and Practice

Gagné typically examined the interaction and dependencies between theory and practice. This is noteworthy given the attention that the application of theory to practice has also received by other researchers. The work of Battersby (1987), Clark (1988), Huberman (1990), London (1972), Schön (1987), and Willis (1993), are but a few examples of researchers who have joined the ranks of researchers who argue that good theory should be applied to practice, and conversely exemplary practice should be examined as a basis for new theory development. Huberman (1990) goes further in linking theory practice by suggesting that researchers should start their research by first contacting practitioners. Furthermore, he notes that ". . . research findings can flow into practitioner settings and craft knowledge can move into research settings as a natural function of the ongoing relationships between both parties feeding more or less automatically into their customary transactions" (p. 387). This kind of relationship, although described by Huberman in 1990, seems to reflect many situations described by Gagné in his early work. For example, Gagné (1962), in his article "Military Training and Principles of Learning" discusses the differences between those learning principles studied in laboratories and their application to military training, and recognizes the difficulties of applying theory to practice.

> I am not asking, how can a scientific approach be applied to the study of training? Nor am I asking how can experimental methodology be applied to the study of training? The question is, rather, how can what you know about learning as an event, or as a process be put to use in designing training so that it will be maximally effective? (p. 84)

Gagné, in the late 1950s and early 1960s, had clearly established an interest in and desire to apply theory to practice. He was especially interested in examining the larger issue of applying theory to training, teaching, and learning with the eventual objective of enhancing both their effectiveness and efficiency.

Gagné's early observations in military training, research, and academic laboratories provided ample evidence of the inadequacy of existing learning theories and principles as vehicles for solving pressing training problems, and the impact of his reactions to these observations was profound. For example, his theory and research findings were applied to the development of training on trouble shooting aircraft electrical systems and electronics. This is one specific area in which I experienced training bearing the earmark of Gagné's theories. The training on trouble shooting I participated in (and later taught) was carefully sequenced hierarchically, and component tasks were intended as mediators that directed the instruction and learning process toward the ultimate objective. Military trainees were evaluated for mastery of prerequisite skills and taught or retaught these skills when necessary. All of these strategies reflect the influence of Robert Gagné.

Gagné's ever-present concern with practice, even in the midst of theory development, continues to benefit education and training. These benefits will be explored here, especially in terms of curriculum development, instructional design practice and transfer of training.

Impact of Gagné's Theories on Curriculum Development Practice

An examination of curriculum and curriculum development logically begins with a concept definition. Although later references to curriculum by Gagné indicate an evolution in his thinking in regard to curriculum, and can be referenced in his several editions of *The Conditions of Learning*, the definition that follows serves as somewhat of a contextual benchmark for the sixties. Gagné (1966) defines curriculum as . . .

> . . . a sequence of content units arranged in such a way that the learning of each unit may be accomplished as a single act, provided the capabilities described by specified prior units (in the sequence) have already been mastered by the learner. (p. 22)

This perspective of curriculum is indicative of Gagné's thinking at that time, and bears strong resemblance to his views of cumulative learning theory (see Chapter 1) and his notion of learning hierarchies (see Chapter 2).

Contrasting definitions illustrate the diversity of thinking in this area at that time. For example, Bruner (1966) defined curriculum as involving "the mastery of skills that in turn lead to the mastery of still more powerful ones, the establishment of self-reward sequences" (p. 35). Furthermore, he suggested that "a curriculum should be prepared jointly by the subject matter expert, the teacher, and the psychologist with due regard for the inherent structure of the material, its sequencing, the psychological pacing of reinforcement and the building and maintaining of predispositions to problem solving" (pp. 35, 70). Eisner (1985) sees curriculum as existing in three forms—null, implicit and explicit. He views the null curriculum as those things not taught and not learned in schools—there simply are no opportunities to learn them. Eisner's implicit curriculum is similar to Bloom's latent curriculum. It is a curriculum in which ideas, values, attitudes and processes are not explicitly taught, but are none-the-less learned. They are learned through the subtleties of teacher values and attitudes, as well as the signals sent by the organization as a whole (e.g., where it puts its resources, and what it values—sports, academics, fine arts, etc.). Finally, Eisner's explicit curriculum is that which students, teachers and administrators must attend to most in schools. It is what parents and society expect students to have learned, and what they try and measure as predictors of success. This curriculum offers tangible evidence of its existence through instructional materials, technology, instructional strategies, guides, etc. The explicit curriculum is often perceived as that cumulative knowledge of human kind that is passed on through the generations. Klein (American Society for Curriculum Development, 1993) defines curriculum as "those activities, processes and structural arrangements as intended for, employed in, or experienced in the school and classroom for the purposes of fulfilling the educative function" (p. 2.16).

Further contrasting definitions are offered by Bloom (1976). He views curriculum as occurring in two forms—visible and invisible. The former being the school subjects one is taught, and the latter being those lessons which teach one his or her place in school.

Bruner and Klein provide views that are more traditional and closer to that of Gagné. Eisner, on the other hand, also recognizes the existence of both formal and informal curricula, similar to Bloom. While not all theorists agree on the definition of curriculum, Gagné's position has been used as the basis for a number of important efforts in schools and training.

School Program Design

The most pervasive example of an application of Gagné's theories and research to a large-scale curriculum project is *Science: A Process Approach* (SAPA), a part of the American Association for the Advancement of Science (AAAS) Commission on Science Education. These science curriculum materials were influential in schools and colleges during the 1960s and early 1970s and represent a significant large scale curriculum effort utilizing Gagné's theories and research in the areas of problem solving and scientific inquiry. Gagné's view of a process approach to science is scientific inquiry and is based on students having a large knowledge base that they subsequently utilize to make and then test inductive inferences. The underlying foundation for the process approach is hierarchical, and presumes that learners have the prerequisite process skills as background. Gagné (1965) maintained that the process approach is a middle ground between the "content approach" and the "creative approach" and "It substitutes the notion of having children learn generalizable process skills which are behavioral specific, but which carry the promise of broad transferability across many subject matters" (p. 4). It can also be said that SAPA and its orientation to teaching elementary science and scientific inquiry, although first published in the sixties, remained immensely influential in science texts and other commercially published science materials well into the 1980s. Andrew Ahlgren of AAAS, co-author of *Science for All Americans*, provided further testimony to Gagné's influence on science curriculum, as well as his indirect influence on mathematics, and technology curriculum in specific (A. Ahlgren, October 3, 1994, personal communication). He stated that SAPA most certainly had tremendous influence on not only science, but also technology curriculum.

Not all see Gagné's influence on science curriculum as positive. Finiley (1983), for example, argues that Gagné's theories, as well as others of like mind, have propelled science curriculum in the wrong direction by advocating a commitment to inductive empiricism.[9] He maintains that a presentation of papers by Gagné to AAAS ". . . has had a substantial influence on curriculum, instruction, and research in science education since that presentation" (p. 47). Finiley then selects Gagné, in view of all others writing about science process, as the most influential when he says: "Although many science educators have written about science processes, the view established by Gagné has been most influential" (p. 48). He continues his argument from a philosophical perspective indicating that Gagné, similar to his predecessors like Francis Bacon, Robert Boyle, Sir Isaac Newton and Hume, embrace the positions of empiricism and induction. Finiley, although in fundamental disagreement with Gagné's approach to teaching science, substantiates the overreaching influence Gagné has had on the development of science through SAPA during the late 1960s and into the 1980s.

Hackett (1971) provides another example of the use of Gagné's theories on a large-scale curriculum project in a public school setting. Although her work was primarily directed toward reading and communication skills curricula, she provides ample evidence of the application of Gagné's theories to social studies and mathematics as well. Hackett's experiments and curriculum projects focused on a performance-based approach that has many similarities to the outcome based education movement of the late 1980s and early 1990s.

There are also many examples of smaller scale curriculum efforts that apply Gagné's theory to curriculum development projects. Two examples are Gilbert's (1992) use of Gagné's hierarchies in his curriculum on questioning and taxonomies, and Lines's (1988) work with advanced economics. These programs provide evidence of more recent applications of Gagné's theories

[9] Finiley, when discussing Gagné's theories is making direct reference to Gagné's influence on science curriculum through AAAS in general and SAPA in specific. The influence, as mentioned earlier, is centered around Gagné's perspective of a process approach where learners are taught to think and solve problems like a scientist would. In Gagné's (1965) scheme this would be accomplished by learning prerequisite skills which transfer to more complex skills, and eventually lead the learner to a level where they are able to carry out scientific thinking which is disciplined and systematic and connected to ". . . the process of science" (p. 4).

to curriculum. One can also examine as evidence Margaret E. Bell's (1982) article in which she makes a persuasive case for the application of Gagné's theories to designing programs. She argues that curriculum design and development has not been as systematic as the efforts of designing instruction. Bell recommends that Gagné's five capabilities can be applied to course instruction as well as program or curriculum development. John Flynn (1992) also adapts Gagné's Events of Instruction to the very high profile and contemporary research area of cooperative learning.

School Lesson Design

When relating Gagné's theories to curriculum efforts that are directed toward individual lessons many of the examples utilize computer technology. Lesgold's (1987) effort wherein goal knowledge was examined as to its significance to ". . . intelligent machine . . . [and] human activity . . ." is an example of adapting Gagné's theories to curriculum and prerequisite skills in a novel way. Also in this category is the Smaldino and Thompson (1990) research relating the Events of Instruction to science education and computer technology. These authors propose designing science lessons focusing on the "Nine Events of Instruction" (p. 17). Jonassen (1988) has utilized many of Gagné's writings, theories and principles in the design of microcomputer courseware. He especially utilizes Gagné's Events of Instruction and his work in the area of hierarchies and prerequisite skills. Jonassen (1988) also utilizes Gagné's work with respect to learning outcomes in designing individual lessons to be delivered by computer courseware.

Training Curriculum Design

Gagné's theories also have been used extensively in training curriculum design in the private sector of business, or the non-school sector of governmental agencies. It is most appropriate to start with the military and defense related environments where the evidence of Gagné's influences significant. Readers having further interest in Gagné's influence on military training should consult Spector's work in Chapter Eight. While many of Gagné's early writings are generously sprinkled with references to military applications and research results conducted in military settings, there are also many current applications made in private sector training. Stepich (1991) and Garavaglia (1993) provide two examples. Stephich (1991) examines the idea of utilizing training to move learners from novice to expert status, and proposes a way to apply Gagné's "conditions of learning" to training design. Garavaglia (1993) suggests that designers take another look at the design phase of Instructional Systems Development (ISD). Garavaglia contends that: "For each event of instruction you should determine the method for which it can be achieved and the media necessary to achieve it" (p. 28). He continues by expanding on how the Events of Instruction can be used in conjunction with Keller's ARCS model in what Garavaglia's calls a technical training submethodology. Both of these articles utilize Gagné's theories to develop techniques, methods or practices and each imply that the practice based upon his theories has implications for a larger curriculum effort throughout a training program in the private sector.

Impact of Gagné's Instructional Design Theories on Instructional Design Practice

The profound impact of Gagné's theories on instructional design practice is one path toward understanding his influence on design practice, and is most easily understood when positioned in the context of his early theories of instruction or learning.[10] The second path is an examination of the practical research reports, journal articles and curriculum projects that report the findings of research, theory development and application to instructional design practice. These resources are more likely to be, in relation to this chapter, reports on the application of Gagné's instructional

[10] The influence of Gagné's theories on instructional design practice reveals two paths which are not only interrelated, but nearly inseparable. The first path is an analysis of textbooks and handbooks. The second path focuses on practical research reports, journal articles and curriculum reports. The instructional design textbooks and handbooks serve many purposes, one of which is to provide a communication link between theory, research and the practice of instructional design in education, educational psychology and training. The argument here is that there are two important goals for texts and handbooks. First, to communicate to the readers' the theories and models found within them; and second, to promote these theories in the respective practices of education and training of their readers.

design theories to specific content areas or disciplines within the educational or training arena. Since the author devoted considerable space and cited several sources from this path when examining Gagné's influence on curriculum, no further effort will be made to elaborate on these items. It is clear however, that Gagné's impact on instructional design practice is evident in the enormous number of journal articles, research reports and curriculum projects that refer to his work. The reader is well advised to pursue these resources or to refer to the curriculum section of this chapter for further information. No specific effort has been made to identify when resources from one or another path are being highlighted other than to identify items as books, reports or journal articles. It is important to realize that he was one of the theorists instrumental in bridging the gap between the behaviorists of the 1950s and 1960s and the cognitivists of the 1970s and 1980s. Case and Bereiter (1984) maintain that when Gagné ". . . shifted the focus of attention from the *how* to the *what* of behavior change; that is, he shifted the focus from reinforcement to the nature of the behaviors themselves" (p. 144).

Case and Bereiter (1984), suggest that Gagné not only moved away from reinforcement, but he also recognized learning as a more complex process than previously thought, and they elaborate on Gagné's recognition that learning was not confined to ". . . the learning of physical behaviors and simple stimulus-response connections but also the learning of concepts, rules, principles, intellectual skills and cognitive strategies" (p. 144). Using Gagné's earlier work as background, they suggest that the third and most important part of his work, which catapulted him beyond the behaviorists of that time, was his concept of sequencing intellectual skills and allowing the instruction to move systematically toward higher-order skills while building on prerequisite skills.

Gagné had a part in the paradigm shift from behavioral to cognitive psychology in the early 1960s, and this brought about a predictable change in both instructional design literature and practice. The literature of the field, viewed as a communication link or mediator between theory and practice, is certainly a measure of just how pronounced his influence has been.[11] There are several series of texts that further explain and apply Gagné's theories for practitioners. An example of a multiple series of texts is the four editions of Dick and Carey's (1978, 1985, 1990, 1996), *The Systematic Design of Instruction*. There are very few practitioners anywhere that haven't taken a course where this text was used, applied it to their practice, taught from it, or at least read it in part. Although the Dick and Carey editions can be characterized many ways, they are theoretically "vintage systems theory" with the strong influence of Gagné in their application of instructional design theory to practice. They also model Gagné's desire to be practical by presenting their system for designing instruction as one that accommodates either a "knowledge" or "product" approach. They add that they favor the product approach since it requires students to actually develop instruction as opposed to learning about instructional design as a theoretical concept. There are many other series and single texts that have been influenced by Gagné's theories and research, and are worthwhile consulting to this end.

Richey (1986) maintains that Gagné has had tremendous influence on instructional design practice through his theories, models, and procedures for developing instruction. Instructional designers have embraced Gagné's theories for many reasons; however, one of the most compelling reasons lies in his work with learning outcomes. Gagné (1988) directs the instructional designer to utilize the following learner outcomes when analyzing content: intellectual skills, verbal information, cognitive strategies,

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[11] Textbooks and handbooks are a primary communication link between theory and practice, and as such they are an essential resource for measuring Gagné's influence. Among his texts are the following: the four editions of Gagné's The Conditions of Learning (1965), the two editions of Gagné and Briggs (1974 & 1979), Principles of Instructional Design and the third edition of the same title by Gagné, Briggs and Wager (1988). These books alone would indicate a monumental impact on instructional design practice since they are cited throughout the instructional design literature that parallels them, and almost all the instructional design literature that follows. They are also texts from which many instructional design practitioners in the 1970s and 1980s learned the theory and practice of instructional design.

motor-skills, and attitudes. Subsequent to determining the desired learning outcome, the instructional designer is advised to complete the content analysis based on the expectations for the learner. The documentation of the design process where the designer selects the appropriate learner outcomes, completes the content analysis and develops the appropriate flow diagrams and procedures becomes the core of the instructional design document used to guide the instructional design project to completion.

No examination of Gagné's influence on practice would be complete without examining the influence of his theories on teacher education and ultimately on teachers, professors, and the entire education enterprise. Furthermore, this examination compels the researcher to delve further into the definition and concepts of influence and change. Short term change in attitudes brought about in pre-service educators being exposed to Gagné's theories in methods and media/technology courses may be assessed traditionally in course evaluations and tests; however, expecting them to incorporate these theories and concepts into their teaching practice is a different matter. This is especially true when considered from the perspective of initiating permanent change on professionals who ultimately spend their careers in an organizational culture which has many years of history, precedence, and accepted methodology, which often reinforces the attitudes of experienced teachers, and thus shapes the attitudes of new teachers. Martin and Clemente (1990) argue that instructional systems design (ISD) has had minimal impact on schools because professionals as well as professors of ISD haven't considered carefully enough their clients (teachers) and the culture of schools. They further argue that until ISD professionals understand that acceptance of the ISD approach should be considered an innovation in schools, subject to all the usual barriers to change, we will be unsuccessful in promoting ISD in schools.

Finally, teachers at the K–12 level, as well as those at the college and university level, have tremendous responsibilities for instructional design. Sometimes the approach is less formal and sometimes less systematic that the tactics employed by designers working in the corporate environment. Many K–12 teachers were introduced to Gagné and the notion of instructional design in pre-service education courses directed toward media and methods of using instructional technology. Such courses can have significant, career-long influence on many educators. Therefore, when preparing instructional design textbooks, instructional design theorists need to consider the organizational constraints under which classroom teachers or corporate designers work. Teachers may look for the most practical, easy to apply aspects of design theory.

Summarizing, the influence of Gagné's theories on instructional design practice spans a gap from a reliance on behaviorism as a foundational theory to the eventual adoption of cognitivism as an underlying theory. Gagné's overwhelming influence on the literature read by practitioners and the researchers who teach them has had significant impact on practice. Finally, the indirect or implicit influence Gagné has had on the informal instructional design practiced by teachers and many professors through texts for preservice education is greater than many writers realize.

Gagné's Influence on the Transfer of Learning

Some might be surprised to see the topic of transfer of learning being addressed in a chapter on practice. It is included here for two reasons. First, Gagné himself emphasized the critical role of applying learning to future endeavors for more than 50 years. But more importantly, its inclusion is based in the assumption that design practitioners are critical stakeholders in the *post*-instruction performance of all learners.

When reading Gagné's work, and especially the four editions of *The Conditions of Learning*, one is impressed with his attention to detail related to the many dimensions of learning and transfer. Gagné discusses often that learning should be generalized to new and varied content and applied to situations in the learner's life. Syllogistically, the argument could be made that through the four editions of *The Conditions of Learning*, and through his work with the Events of Instruction, Gagné always had been, and continues to be, dedicated to both near and far transfer.

Gagné (1989) was experimenting with the transfer of training as early as the late 1940s. This early research examines positive and negative transfer and discusses transfer in the context of giving: ". . . different amounts of training to separate groups of subjects on an initial task which was a subordinate part of a total skill involving four differential manual reactions" (p. 22). This research was done with training subjects on complex motor tasks using multiple trials and observing them for periods of little or no improvement (plateaus) in learning. In this study the control group performed better than the group with too few trials (negative transfer). The control group was out-performed by the group having optimal trials (positive transfer). Positive and negative transfer are defined in many ways; the following definitions by Broad and Newstrom (1992) serve as a reference point for the examination that follows.

> *Positive transfer*—a situation in which prior learning assists in acquiring new knowledge or skills.
> *Negative transfer*—situation in which prior learning interferes with acquiring new knowledge or skills. (p. 181)

Gagné's early views on transfer parallel the previous definitions. Moreover, his work involving positive and negative transfer became the basis for his later concept of transfer which has been so thoroughly embedded in the practice of instructional design.

The discussion that follows is centered on Gagné's evolving concept of transfer over a 20-year span. During that time frame his use of the term was modified from one which differentiated between positive and negative transfer to the more contemporary lateral and vertical concepts found throughout the literature and utilized by practitioners today.

Gagné (1962), when referring to transfer, builds upon the concepts of positive and negative transfer. When discussing transfer in the context of applying training to new situations where the knowledge and skills are critical Gagné says " . . . transfer of training from component learning sets to a new activity which incorporates these previously acquired capabilities" (p. 364) he seems to be directing his focus more toward generalization, which becomes the focus of his later conceptualization and subsequent definition of transfer. Gagné (1965), when discussing external events and the conditions of learning, indicates the need for what has been learned to be ". . . generalizable, and transferable . . ." (p. 206) to new and different situations where it might be applied.

Gagné (1970) says that capabilities learned in school should provide students with the background and skills to accomplish practical things in their lives or in occupations and identifies this as lateral transfer. Furthermore, he says students should be able to learn more complex things as a result of their previous learning. This learning of more advanced or complex tasks or skills based on subordinate rules or concepts is called vertical transfer. The defining of lateral and vertical transfer within the framework of the conditions for learning helped establish the foundation for applying the concept of transfer to contemporary instructional design practice.

Some lesser known facets of Gagné's theories of learning and instruction are both an indication of his continued search for unique ways of solving learning and instructional problems, and his willingness to examine the contrasting work of other researchers. Gagné (1968) offers the cumulative learning theory to those practitioners having some difficulty with total acceptance of his hierarchical or taxonomical theories. Although hierarchical in the pure sense, the cumulative learning theory offers a modified approach to learning and transfer (see Chapter 1). His explanation of this theory begins with his contrasting two models of intellectual development, one by Hall and Gessell and another by Piaget. Gagné also examines two kinds of capability change, both of which are observable and distinguishable by the time frame required for the change to take place. Those changes in behavior capabilities that occur in hours, days, or weeks are referred to as learning and memory; those behavior capability changes requiring months or even years are called development. One of the many questions surrounding the difference between learning and development is that each view transfer of learning from a different perspective.

Further examination of Gagné's theories, especially those related to human development, shows the relationships between his cumulative learning model and transfer of training. Gagné maintains that the use of the cumulative learning model will enhance transfer. In other words, learned capabilities at any stage of the model (stimulus-response connection, a concept, a simple or a complex rule) are likely to facilitate demonstration of the hierarchy's pinnacle task, as well as other related tasks. "Cumulative learning thus assumes a built-in capacity for transfer. Transfer occurs because of the occurrence of specific identical (or highly similar) elements within developmental sequences (Gagné, 1988, p. 338). Gagné (1988), when referring to "stages" or "levels" in reference to learning new material related to previously learned material, states:

> Cumulative learning thus assumes a built-in capacity for transfer. Transfer occurs because of the occurrence of specific identical (or highly similar) elements within developmental sequences (p. 338).

Gagné, adds that the term "elements" has specific meaning in this discussion of transfer since it refers directly to ". . . rules, concepts, or any of the other learned capabilities . . ." (p. 338).

However, the larger question here is: do instructional designers, engaged in the process of practicing their instructional design skills and selecting learning theories automatically consider cumulative learning as a theory? The author's bias leads him to the conclusion that a large percentage of practitioners are not familiar with it and utilize it much less in their practice to enhance transfer. Designers familiar with theories which are not "mainstream," whether Gagné's or others', face the dilemma of either returning to what they know best, or experimenting with fresh approaches. This is especially difficult when deadlines are shorter, and there is increasing pressure to decrease the design cycle time.

When considering Gagné's transfer theories and their relationship to intellectual skills and higher order capabilities, it is evident that Gagné accepts the proposition that intellectual skills and higher order capabilities may be learned for a specific intent or objective. These then become the background for generalization or transfer. The generalizations made by the learners may be a result of planned instruction, while in other cases students may take the initiative to learn them independently. Since learning ascribed to this theory is cumulative, it often becomes more complex in the process of development; therefore, generalization and transfer between and among those things already learned and those to be learned is enhanced. Gagné (1988) when commenting on the process of transfer says: "There is no magic key to this structure—it is simply developed piece by piece. The magic is in learning and memory and transfer" (p. 332).

Summarizing the preceding definitions and discussions of transfer and their implications, Gagné's perspective is clear: the most important aspect of transfer is its dependency on what has already been learned. In short, there is nothing to transfer if it hasn't already been learned. The second criteria, and equally important to transfer, is the necessity to vary the situations and possibilities in the training environment.

The concepts of far and near transfer have significant ramifications for instructional design practitioners since the design process is grounded in the learners applying their acquired learning to both similar and novel situations and environments from those in which they were trained. Far and near transfer are similar to Gagné's definition of lateral and vertical transfer. Their similarity can be found through examining the functions of subordinate skills and content complexity. Near transfer is concerned with application of instruction similar in complexity to the training, where far transfer has the expectation of generalizing or applying learning in situations and contexts that vary from the original training. A similarity between near and lateral transfer can be found in their expectation of applying concepts and procedures to problems or situations equal in complexity to those practiced in the instruction. Moreover, both vertical and far transfer have the expectation that learners apply their learning to new concepts and problems, often more complex and unlike those presented and practiced in the original instruction. This brings the discussion to the internal dimension of both vertical and far transfer. Vertical and far transfer rely on the learner having mastery of a variety of knowledge, information and skills which in turn enhances the possibility of transfer occurring. The practicing instructional designer should build in a positive environment for learning. This environment should strongly encourage learners to experience "real life" situations in their instruction and to test their perceptions of the concepts and information with other learners while they are being taught.

Although most researchers and theorists in the domains of instructional design, educational psychology and education support the concept of transfer, there are those who question the underpinnings of the transfer theories posited by Gagné and others of like mind. Singley and Anderson (1989) have written an entire book addressing transfer from the perspective of it occurring with respect to cognitive skills. Although they have devoted considerable effort to their investigation of transfer, Singley and Anderson question some of the premises related to vertical transfer and the effectiveness of hierarchical analysis and the identification of prerequisite skills as a method for enhancing transfer in curriculum design. They don't rule out the possibility of the success of this method; however, they question the effectiveness of it and recommend more specific research in this area.

Application of Gagné's transfer theories to contemporary instructional design practice are many, but few are any clearer than Dick and Carey's (1990, 1996) discussion of goal analysis and subordinate skills analysis. They suggest that focusing on what learners need to know rather than what the learner must do, can easily mislead designers. Furthermore, they insist that when analyzing sub-skills, the designer must ask what is it that the student must already know how to do? If the pre-requisite skill is absent, then is it impossible to learn this subordinate skill? This rhetorical question is a clear indication of the impact of Gagné's work on these authors and subsequently on instructional design practice, since it is found in this high profile and widely used practitioner text.

Summary and Conclusions

Attention here will be directed toward bringing closure to the discussion of the lasting influence Gagné's theories have had on practice. Further discussion of salient research, theories and practice presented in the chapter will be included.

Perhaps the best place to start is with Gagné (1989) himself. In the Preface to *Studies of Learning: 50 Years of Research*, Gagné says:

> Learning theory has maintained its interest for me over many years. However, the questions addressed in my research have usually been practical ones, or at least have been strongly influenced by practical considerations (p. 6).

This statement and others made in the preface of his book reflect Gagné's perception of his efforts to use research and theory to solve practical problems. As Gagné nears the end of the preface, in what appears to be an introspective comment about life choices, he says: "My move to Florida State in 1969 was the beginning of a concentrated effort devoted to teaching and writing in the field of instructional design" (p. 6). Gagné seems to be acknowledging here that his intention was to link his vast research and theory base in instruction and learning with learners and the profession through teaching and writing.

Gagné's perception of his life's vision seems to be one of research and writing which initially focused on learning, and eventually, moved toward important contributions to instructional theory. Gagné has, through his unwavering examination of the practice of instruction and learning, contributed greatly to the building of a foundation for the field of instructional design. Clearly his interest in learning in schools and curriculum is evidence of his interest in applying his theories to practice. His evolution from experimental psychologist to an instructional and learning theorist, whose focus became one of application of cognitive theories to instructional design, is indicative of not only his flexibility, but also his interest in instructional design practice. His place in the history of instructional design practice is most certainly secure from both a foundational as well as an application perspective.

Concluding the examination of Gagné's influence on curriculum, it is clear that his work has been significant. Evidence of his influence can be found in the many applications of his theories and research to a wide variety of content areas, age levels and learning environments. Additionally, his theories have withstood the test of time having been applied to curriculum of various types over the course of 50 plus years. As mentioned earlier his influence on the curriculum of science has perhaps been most broad based, long-lasting and nationally acclaimed.

Will Gagné's theories endure now that practicing instructional designers, curriculum specialists, and educators have many options when designing instruction? A partial answer might be found by revisiting an interview Gagné had with the editor of *Educational Technology* in 1982. The editor asked Gagné if he thought instructional design would eventually transition entirely from behaviorism to cognitive psychology or would there remain a behavioral presence. Gagné responded by saying:

> I think that designers who work with cognitive learning theory in mind really incorporate the important parts of behavioral theory. Therefore, I think the answer to your question must be "yes." I do believe that the cognitive approach will come to dominate, if it hasn't already. (p. 580)

Does Gagné's response, from 17 years ago, offer us any clues to the lasting impact of his theories? The answer is "a qualified yes," since designers are often pragmatists in their everyday practice of instructional design. Subsequently, they will select those theories and elements of theories that seem logical and have a high probability of working in the situations and environments in which designers find themselves.

A final comment on Gagné's future influence on curriculum must consider the writers, researchers and theorists in curriculum publications. These documents would lead one to conclude that constructivism will be the dominant force in curriculum construction in the new century. Earlier, when discussing curriculum, it was noted that Gagné was cited only once in the 1991–94 *ASCD Handbook* and three times in the 1997 *Handbook*, and all citations related to technology in education and instruction. However, these ASCD publications have many citations, methods, and corresponding activities that are very situated, constructivist, and problem-based in nature.

Returning to Finiley's work may offer another perspective for the reader. Finiley's criticisms of Gagné in 1983, which were fundamentally philosophical, might have been harbingers to the late 1980s and early 1990s. One thing seems clear, if a majority of the theorists perceive the differences between constructivist philosophy and Gagné's inductive empiricism to be irreconcilable, this may eventually decrease Gagné's influence on instructional design practice and curriculum construction. However, another scenario may be, that practitioners will utilize Gagné's theories more selectively.

The genesis of Gagné's theories found their way into my practice before I knew they existed or what they were, and 10 years before I heard the name Robert M. Gagné. I learned from the instruction, which I believe was designed using his theories, because it was logical, provided me with enough practice to reach mastery and subsequently be successful. I taught from the instructionally designed materials that utilized his theories because they were comprehensive, were well planned, and they worked. I continue to utilize his theories selectively, 29 years later, as a significant part of my practice for many of the same reasons. Gagné's theories will continue to evolve as scholars analyze his work in search for new meaning. Gagné has a lasting place in the future of instructional design and educational practice. His theories and positions will undoubtedly be reinterpreted, modified, and expanded, but his prominence is likely to remain.

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Chapter 8

Gagné's Influence on Military Training Research and Development[12]

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> *"This I sat engaged in guessing, but no syllable expressing*
> *To the fowl whose fiery eyes now burned into my bosom's core;*
> *This and more I sat divining, with my head at ease reclining ..."*
>
> *Edgar Allen Poe*

The educational psychology research and development literature is filled with references to the works of Robert M. Gagné. This is most especially true with regard to military publications in the specific area of instructional systems development (ISD). Gagné's contributions to educational psychology and instructional technology are quite significant based on such simple measures as numbers of references and citations in refereed publications. When deeper measures are applied, then his significance and impact grow dramatically.

[12] The ideas expressed herein are solely those of the author and do not express the views of the United States Air Force nor of Syracuse University.

My familiarity with Gagné occurred in the context of research and development in support of military training. I shall present a brief overview and indirect critique of his many contributions in this area. Because Gagné has been so prolific for such a long while, I cannot do justice to all that he has contributed to military training research. What I can do is highlight some of his more recent contributions that will illustrate an active and inquiring mind still at work on challenging problems. In discussing a career of dedication to improving education and training in the military, I shall present a picture of the quality and character of the person who has made these contributions.

A Review of Gagné's Military Research and Development

I shall divide this short section reviewing Gagné's contributions to military training research into four sub-sections. The first will focus on his work at several research laboratories. The second section will review his contribution to an automated tool to support the design of instruction. The third will highlight his role in starting a new research journal intended partly as a publication vehicle for work initiated at government laboratories. Finally, I will mention the key role his ideas have played and continue to play in prescribing how instruction is developed in the military.

Research at Military Research Laboratories

Gagné had a long and distinguished record of involvement with military training. He served as an aviation psychologist during World War II. At the end of World War II, as a young officer in the Army (U.S. Army Air Force), Gagné was part of the Psychology Branch, Aeromedical Laboratory at Wright Field in Ohio. This unit included a number of distinguished psychologists, including Paul Fitts, the chief of the Psychology Branch, Judson Brown, Launor Carter, Albert Johnson, and Walter Grether, all of whom subsequently made many contributions to aviation psychology and other areas of psychology (see Fitts, 1947).

The Air Force formed a center for personnel and training research that contained a number of laboratories at several locations. In the 1950s, Gagné served as the Technical Director of the Air Force Maintenance Laboratory at Lackland Air Force Base, Texas, and also as the Research Director of the Perceptual and Motor Skills Laboratory at Lowry Air Force Base, Colorado. Gagné published an article in the *American Psychologist* in the early 1960s which represented a consolidation of many of his findings from military research. The article highlighted a variety of areas ranging from perceptual abilities to personnel selection research (Gagné, 1962), and formed the basis for *Conditions of Learning* (Gagné, 1965).

Gagné then pursued a remarkable academic career at Florida State University. He retired with the rank of Professor Emeritus in the mid-1980s. During this academic period, Gagné continued to consult various military laboratories, including the Air Force Human Resources Laboratory, which later became part of Armstrong Laboratory. During this period, he was a frequent presenter at conferences and meetings arranged by the various military training research laboratories. For example, Gagné was the featured speaker at several meetings of the American Educational Research Association by invitation of the Military Special Interest Group. He was also the keynote speaker at many government training research meetings, including an international conference on the subject of distance learning hosted by Armstrong Laboratory in 1990.

Subsequent to his retirement from academia in 1991, Gagné went to Armstrong Laboratory as a National Research Council Senior Fellow and worked with a research team building tools to support designers and developers of military training. More details about his activities while there will be discussed later in this chapter.

This represents 50 years of involvement with military training research and development, a record that is not even closely approached by any other individual. To say that Gagné influenced military training has to be one of the understatements of the century. It would be more accurate to say that he was instrumental in defining a framework for effective military training.

Guided Approach to Instructional Design Advising (GAIDA)

In 1989 Gagné was invited to be one of seven academic advisors on the Advanced Instructional Design Advisor (AIDA) project (Spector, 1990). The overall goal of the AIDA project was and is to provide subject experts who have little experience in course and lesson development with guidance and support tools to enable them to perform more effectively.

The initial result of the first phase of this project was that three types of approaches were suggested as worth pursuing. Gagné (1993; Gagné, Tennyson, & Gettman, 1991; Spector, 1993) argued that a useful approach would be to provide content specialists with meaningful examples of good instruction similar to types they were expected to design, along with high level guidance for instructional design elaborated in terms of those examples. Merrill proposed a system inspired by transaction theory (Merrill, 1993). Tennyson (1993) provided a vision of an elaborate suite of tools and a rich library of instructional design resources. The Laboratory decided that Gagné's proposal could be prototyped and tested. The chief of Instructional Design Research, Scott Newcomb, invited Gagné to join our research team as a National Research Council Senior Fellow for this purpose. The result was the creation of a program that initially had one sample lesson and an elaboration of its design principles. We called this program the Guided Approach to Instructional Design Advising (GAIDA). (We had intended the 'G' to stand for 'Gagné', but he was much too modest to allow this to happen.).

GAIDA began to generate some interest both within the Air Force and with outside users. Additional sample lessons or cases were added with appropriate elaboration as to why they were designed as they were. The cases were selected to represent key types of learning (verbal information, intellectual skills, and cognitive strategies), and when GAIDA was formally released to the Air Education Training Command in 1995, there were six cases. One case was aimed at an identification task (recognizing naval officer insignia). Another case was aimed at a classification task (classifying electronic resistors in accordance with the color code). Two were aimed at procedural tasks, one performed with a checklist (checking the gatling gun on an F–16 aircraft), and one which had to be performed from memory (testing a patient's breathing capacity). One case involved both intellectual and physical skills (handcuffing). The sixth case in the 1995 edition involved complex skills that had to be performed in close coordination with others (flying formation procedures). Other cases have since been added, including the use of multimedia in classroom instruction, handgun safety instruction, and guidance pertaining to discussion groups and lecturing.

The overall lesson framework for all the cases was the nine events of instruction. At that time (in the early 1990s), the Air Force Human Resources Laboratory had close collaborations with the Navy Personnel Research & Development Center and with the Army Research Institute. As a consequence, findings from those laboratories made their way into GAIDA, and GAIDA made its way into the Navy and Army as well as the Air Force training research communities.

These inter-service exchanges led to a particularly useful feature of GAIDA, inspired by Gagné's commitment to and respect for differences in individuals as well as in organizations. The feature is this: everything in GAIDA was designed to be replaceable. The individual cases could be replaced or new cases could be added by following a simple convention of indicating where the guidance program could find an instance of each of the nine events. The generic elaborations of the nine events could be replaced by improved versions or by versions more in line with local practice or local language usage. The specific elaborations for the design of the lessons were also easily alterable or replaceable. Finally, the guidance offered specifically for the design of multimedia was just as easily replaceable. A special booklet describing how to customize GAIDA was produced and distributed with early versions. The general assumption behind this modularity was that learning was at least partly influenced by local learning cultures, practices, and language usage (Spector, 1995).

While I believe this assumption is still valid, I must also report that in the three years of GAIDA use in this highly modularized form with more than 100 users, there was never a single case of the program being modified in any of the ways just indicated. This might be a result of reluctance to undertake what might be viewed as a programming task, although in most cases the changes involved only the alteration of text using a word processor. No formal study was conducted to determine why GAIDA was never customized to fit local practice. Informal reports, however, indicate that GAIDA was easily used and that users quickly graduated to higher levels of competence, so that such modifications were not necessary.

Training Research Journal

While working on the GAIDA project at Armstrong Laboratory, Gagné consulted with a variety of researchers on many topics. One thing that Gagné found particularly attractive about the Laboratory was its inter-disciplinary approach to training research. There were and are a significant number of cognitive psychologists, computer scientists, human factors specialists, organizational psychologists, and the odd philosopher. Gagné found this mix of people and expertise intellectually stimulating.

One problem he decided to personally address was the lack of publication opportunities for such interdisciplinary research in the area of training. He was instrumental in founding the *Training Research Journal* and serves as its consulting editor. This journal was published by Educational Technology Publications, and had as its stated purpose the synthesis of theory and research pertaining to training from multiple fields. Its original editorial board included two researchers from Armstrong Laboratory, a Navy researcher, and a researcher from the Institute for Defense Analysis. This annual journal represented a major contribution to the publication of research and development initiated in military settings, and its first publication in 1995 contained a recent article reflecting Gagné's continuing strong interest in internal cognitive processes and their implications for the design of instruction (Gagné, 1995).

United States Air Force Manuals on Instructional Systems Development (ISD)

The United States updated and revised its regulations and procedures pertaining to the design and development of instructional systems in the 1990s (USAF, 1996a; USAF, 1996b). The previous regulations and procedures were significantly influenced by Gagné and reflected much of his work and writings in the 1970s and 1980s (see, for example, Gagné, 1985). Missing in the Air Force procedures and practices of that era were guidelines pertaining specifically to the design and development of interactive courseware and procedures reflective of actual and desirable practice (e.g., rapid prototyping of courseware with early formative feedback from targeted learners).

The Air Education and Training Command (AETC) had advisors working with the AIDA research team, especially in the needs assessment and training requirements analysis phase. As a consequence, Gagné and others from the AIDA research team were recruited by AETC (then called the Air Training Command) to update and revise Air Force policy pertaining to instructional systems development.

In addition to having a very direct say with regard to Air Force policy in the area of instructional systems development (a major enterprise in the Air Force), Gagné's work on GAIDA made its way onto a CD-ROM which was distributed with the revised policy manuals and handbooks. As of this writing, this material is also available on the Internet at this address: http://www-technet-aetc.af.mii/links/isd.htm.

Illustrative Encapsulations

Individual Differences

Gagné's works do not typically involve deep or sustained treatment of individual differences. This is not an indication that he had no particular interest in this area. Rather, it reflects his belief that the design of instruction (as opposed to its delivery or its interpretation) is based more fundamentally on an analysis of the subject matter. Gagné (1995) is certainly aware of internal cognitive processes as well as significant cultural and individual factors which might influence the design of instruction, as indicated by the design of the original GAIDA architecture, applying principles typically associated with situated learning and cognitive apprenticeship and socio-historical perspectives. The following story is intended to illustrate Gagné's understanding and thoughts pertaining to individual differences in the area of map interpretation.

As previously mentioned, Gagné was a National Research Council Senior Fellow at the United States Air Force Armstrong Laboratory in 1991–1992. Gagné's specific task and challenge was to guide the construction of the lesson planning advisor he had devised as a consultant on the AIDA project (Gagné, 1993; Spector, Polson, & Muraida, 1993). He began with an open-minded revalidation of his nine events of instruction in the context of military training. Those nine events (see Chapter 4) are as follows: gain attention; inform the learner of the objective; stimulate recall of prior learning; present the stimulus material; provide learning guidance; elicit the performance; provide feedback; assess performance; enhance retention and transfer (Gagné, 1985). The primary question that he was investigating was whether military trainers in fact designed and delivered instruction in ways that were compatible with those nine events. A secondary question was the degree to which his explanations of those events were easily understood by military trainers. The outcome of these investigations was generally positive, and the system already described as the Guided Approach to Instructional Design Advising (GAIDA) was eventually constructed, evaluated, and implemented (Gagné, 1992).

Gagné had visited the security police-training group at Lackland Air Force Base and had worked with a new instructor there who was teaching handcuffing procedures, among other subjects. Gagné first observed a few lessons and then decided to have the instructor videotaped along with a videotaped segment by Gagné concerning the nine events of instruction. This particular novice instructor was intuitively following the nine events, and he appeared to be both enthusiastic and successful in training this particular handcuffing procedure, making him an excellent choice for an illustrative video for military trainers concerning the nine events. In the course of Gagné's year and a half at Armstrong Laboratory, this videotape was digitized and became one of the lesson exemplars in GAIDA.

Near the end of Gagné's tenure at Armstrong Laboratory, he decided that he would like to have several copies of the videotape, especially for colleagues who had learned about this activity. I had the pleasure of driving Gagné back to the audio-visual office at Lackland Air Force Base. I knew about where the office was, and I naively assumed that if I got close Gagné would recognize the particular office. This strategy failed, and we circled for some time looking for a building that he might recognize. Finally, after a bit of frustration, Gagné suggested that we leave the Air Force Base and re-enter through the very same gate that he had used on his initial visit to the audio-visual office. I resisted this suggestion since I knew we had to be quite close, but he managed to persuade me that this strategy would work. When we re-entered the base, he looked at no landmarks. He merely recited from memory the instructions that he had received on a piece of notepaper a year and a half earlier that he had long since thrown out. His memory was perfect. We arrived at a building just next to where we had been less than a half-hour earlier. He then repeated the instructions to get us from the parking lot to the specific entrance and office; his memory was again perfect.

Gagné demonstrated extraordinary memory capabilities on other occasions as well. I recall a dinner at the Association of Educational and Communications Technology Conference in Nashville. I introduced Gagné to Gustav

Schulz, a visiting German researcher at the Laboratory working on a German version of GAIDA. Gagné apologized for not remembering any of the German he had learned in his university studies, but then managed to recall a somewhat lengthy poem in German, which Gustav immediately recognized as a popular favorite.

This experience re-locating the audio-visual building sparked a discussion on the way back to Brooks Air Force Base about the need to take into account individual differences and preferences when designing both maps and instruction. Gagné reported his clear preference for lists of instructions as opposed to visual landmarks with regard to maps. I remarked that I could more easily recall descriptions of visual landmarks and suggested that map designers might be more successful if both kinds of preferences could be accommodated. He said this was most probably true, but that the analysis of the domain was essentially not changed. There remained a common need to identify an end point or goal and to assume one or more starting points. Many of the relevant in between considerations remained the same for both representations as well (e.g., the length of time required to get from one point to another). What changed were presentation details of the instructions for each type of representation.

He mentioned two additional items. First, the visual representation was not entirely visual. Good visual representations typically included a great deal of textual information. Moreover, cost and time to produce the instructions might be a factor. Listing a sequence of turns was quick and easy and would work with the widest possible audience. He said something to the effect that it is not always necessary to pander to particular preferences; people were neither stupid nor irrational.

Gagné's confidence in the general ability of people to make sense of complicated matters came through on many other occasions, and it formed the initial hypothesis behind GAIDA: Given appropriate high level reminders and good examples, inexperienced courseware designers could and would manage to design meaningful lessons. The courseware designers in question were enlisted military training specialists with extensive subject matter knowledge who were typically highly motivated, task-oriented, practically-minded individuals. Gagné's intuitions with regard to GAIDA have certainly held true. It became widely used in the Interactive Courseware Developers course at Sheppard Air Force Base and was distributed within the Air Force on a CD-ROM containing the revised Air Force manuals on instructional systems development.

Again, this is an indication that the extent of his involvement in military training research and development went well beyond research to close and careful case studies with enlisted personnel as well as to the highest levels of policy making. His influence has been *pervasive.* In addition, these activities late in his career clearly demonstrate that his interest in and influence on military training were not a passing fancy. In 1992, Gagné was officially recognized for these many achievements by the Commander of the USAF Systems Command, General Ronald W. Yates. General Yates specifically cited Gagné's long-standing commitment to improving the quality of military training and his many significant influences on military personnel and training research.

Learner Engagement Story

On another occasion, Gagné and I were driving around Phoenix looking for a particular restaurant. This time, however, he had no list of instructions to recall as another person had previously taken him there. To complicate the situation, he did not remember the name of the restaurant—only that the food was excellent. Not surprisingly, it took us quite a while to find the place. While driving about, we happened to take up the subject of learner engagement. I was worrying about how to construct guidelines for designers and developers of military training environments. Specifically, I was concerned with the possibility of constructing automated mechanisms for dynamically engaging learners when they began to lose interest and motivation or when progress appeared to be lagging. I was wondering how one judged another's level of engagement. If we did not know how human tutors did this, then it seemed unlikely that machines could be programmed to judge and respond to learner engagement. His initial response was that this was easy as there were obvious verbal and visual cues used by human tutors.

I was skeptical as I recalled an AIDA meeting which included a panel of expert instructional design researchers and psychologists, including Henry Halff, David Merrill, Harry O'Neil, Martha Polson, Charles Reigeluth, Robert Tennyson, along with Bob Gagné and various military advisors. After a break for lunch at the Brooks Officers Club, the meeting proceeded with a discussion about the appropriateness of the instructional model used in one of Merrill's more recent systems (Merrill, 1993). There was a lengthy discussion about a technical matter pertaining to learner control. The discussion was partly brought about by Merrill arguing against the general advisability of extensive learner control when teaching novice maintenance technicians about the fundamentals of a particular device and yet allowing so much learner control in lessons generated using ID Expert 3.0. Gagné had long since put his head on the table and appeared to have been asleep for most of this hour-long debate. All of a sudden we heard two fists pound down on the conference table, followed by a short expletive—Gagné had been fully engaged following this discussion while we all thought he was asleep. His summary of the discussion clearly indicated that he had not been sleeping, and his critique indicated that he had followed all aspects of the argument.

Gagné said trainers need to guide learners when the learning goals were specific and well structured, as is typically the case in military training. He went on to say that insofar as learning is a purposive and goal-driven activity, then we should apply some principle of rationality, implying that goals can be identified as well as effective means to achieve those goals (Spector, 1995). Completely open-ended learning environments follow a principle of irrationality in the sense that learners are not expected to have specific learning goals or know effective means to achieve those goals. Gagné found such assumptions deeply troubling, which is why he had reacted so strongly.

Anyway, I had remembered how impressed I was at the time by his intellectual stamina and by how easy it was to make mistakes with regard to someone's level of attention and involvement. While driving about, I reminded him of this incident, and he smiled in recognition of that meeting. He said something about the fact that mistakes can be identified and corrected, so my objection lacked substance. Gagné had this wonderful ability to tell you that you were confused without making you feel small or stupid. On the contrary, he spent a great deal of time while at the laboratory talking with researchers and technicians at all levels about any number of subjects.

Not wanting to drop the discussion, but not knowing how to proceed, I then asked what makes a poem memorable, remembering his recollection of the German poem. Without hesitation, Gagné answered that the rhyme and meter made poems memorable. We discussed the distinction between ease of memorizing and being memorable, as I worried that something had been overlooked. I asked him if he remembered any poems. Then, a most remarkable event occurred. He proceeded to recite the entire poem "The Raven," by Edgar Allen Poe, without pausing to recall a single part. For those readers who may not know this poem, which also happens to be one of my favorites, it is quite long—more than 1,000 words, usually occupying several pages. I asked when he had learned that poem. He said it was about 50 years ago, and he had not given it much thought or attention since. I was intrigued. I asked if he had learned it for a literature course, which is where I first encountered it. He replied that he had found it on his own when he was first dating Pat, whom he subsequently married. Why had he committed it to memory? He said that he was concerned about matters of the heart, especially the ability of love to endure, as a consequence of his relationship with Pat.

The conversation then shifted briefly to love—a holistic kind of engagement, as opposed to the more cognitive kinds of engagement we had been discussing. As I recall, we both came to the conclusion that we knew very little about this deeper kind of engagement, and then we somewhat unexpectedly happened to find the restaurant. I should add that he managed to nurture and enjoy a lifelong marriage with Pat. My conclusion at the time was that he had an incredible capacity for memory as well as for love.

Conclusion

I realize that my review of Gagné's many contributions is much too abbreviated to be complete and thorough. I also realize that many others could recount countless anecdotes to illustrate Gagné's character and encapsulate his perspective on training in the military. I chose to relate the above stories because I wanted to emphasize the quality of his memory, his great respect for people performing complex and demanding tasks, and his generosity of time with very junior researchers and technicians. In addition, I have mentioned a bit about his dedication to family. I should add that he had an insatiable appetite for ideas. He borrowed and read numerous of my books on epistemology. He was most intrigued by Hume's *A Treatise of Human Nature* (1978) for some reason or other.

I have attempted to say in a number of ways just how much military training professionals owe to Gagné. Perhaps the debt is so obvious that it stands on its own without further elaboration. Believing that to be true, I have offered a different kind of elaboration—one that is intended to provide a more personal glimpse of a truly great mind and a wonderfully engaging individual.

> *"Ah, distinctly, I remember it was in the bleak December*
> *And each separate dying ember wrought its ghost upon the floor.*
> *Eagerly I wished the morrow; vainly I had sought to borrow*
> *From my books surcease of sorrow ..."*
>
> *From "The Raven," by Edgar Allen Poe.*

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Chapter 9

Gagné and the New Technologies of Instruction

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Some people would say that very little in the field of Instructional Technology has not been influenced by Gagné's ideas. The various chapters in this book only begin to chronicle the wide-ranging impact of his work. Others would say that Gagné has had no influence on the new technologies of instruction. He is an instructional theorist after all, not an engineer who designs and builds new technological devices. Therefore, before describing the impact of Gagné's work on the new technologies of instruction, it is necessary to reconcile these two positions. In order to do so, this chapter will begin with a discussion of what is meant by technology in general, and the new technologies of instruction in particular. With some common ground established, it will then be possible to describe those areas where Gagné's work has had an impact on the development and utilization of these new technologies, before some final speculation about how Gagné's ideas may be expanded in the future.

Technology, Instructional Technology, and the New Technologies of Instruction

Ask the ubiquitous "person on the street" to define technology and you are likely to hear descriptions of machines and devices—computers, cellular phones, space ships, or televisions. Indeed, modern civilization is inundated with technological devices, hurtling us toward a future where changes brought about by technological innovations are occurring at an ever increasing pace (Toffler, 1972). We have entered a period in human history where technology is so pervasive that we may have lost control. Unlike previous centuries, machines are now used to make other machines; some devices are so small that the human hand cannot possibly manufacture them. We have also reached a point where digital information has become the basic unit of communication (supplanting the printing press), and technology is contributing to changes in nearly all aspects of society (Apple, 1986).

In general terms, technology can be defined as "the systematic application of knowledge to practical tasks" (Galbraith, as cited in Heinich, Molenda, Russell, & Smaldino, 1999, p. 18). In this sense, various technologies might be classified as either "hard" or "soft" (Heinich, Molenda, Russell, & Smaldino, 1999), or as "resources" and "processes" (Seels & Richey, 1994). Hard technologies are developed through the application of physical science and engineering concepts, resulting in new devices meant to accomplish practical tasks (Saettler, 1968). Planes, trains, and automobiles, as well as devices utilized in education such as computers, televisions, and chalkboards, are all examples of hard technologies. Soft technologies are process oriented, applying research from the behavioral sciences to improve human performance (Saettler, 1968). Methods such as needs assessment and task analysis, or various instructional strategies and tactics, are examples of soft technologies used in education and training.

When the practical task is instruction, we try to apply knowledge about learning and teaching so learners might attain specific outcomes after experiencing the series of teaching/learning events that we design and implement. Just as technology can be classified as hard or soft, instructional technology has long struggled with an identity that divides the field along lines that distinguish media from method. For much of its history, instructional technology has been associated in the minds of many people with audiovisual instruction. Decades of research focused on media and its resulting effects on learning (see Clark, 1983; Kozma, 1991). Early attempts to define the field of Instructional Technology incorporated the media/method distinction, characterizing Instructional Technology as "the efficient utilization of every medium and method to promote learning" (Ely, 1963, p.19), or as the "media born of the communications revolution which can be used for instructional purposes," along with a "systematic way of designing, carrying out, and evaluating the total process of learning and teaching" (Commission on Instructional Technology, 1970, p. 21). Gagné also noted these distinctions in identifying the knowledge sources, resources, and activities that constitute the field of Instructional Technology. His definition focuses on a concern for the "conditions necessary for effective learning" (Gagné, 1987, p. 3), including both communications to the learners that are "frequently delivered by equipment and its associated procedures, commonly referred to as media" (p. 6), as well as concern for the techniques of instruction that "systematically aim for effective learning, whether or not they involve the use of media" (p. 7).

The most recent definition of Instructional Technology provided by the Association for Educational Communications and Technology (Seels & Richey, 1994) is now more comprehensive, reflecting the maturity of the field. Instead of distinguishing between media and method, Instructional Technology is now seen as "the theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning" (Seels & Richey. 1994, p. 9). This new definition allows the present discussion of Gagné's impact on the newer technologies of instruction to include not only resources and processes (hardware and software), but also the knowledge sources and practices of the people who design, develop, utilize, manage and evaluate instruction. The significant contributions to the knowledge and practice of Instructional Technology made by Gagné have been well documented. This chapter will focus on how Gagné's work informs the utilization of hardware and the design of software for instruction that incorporates some of the newer technologies.

Knowledge Sources

It would be arrogant to imply that all of the knowledge utilized in Instructional Technology was produced by people closely involved with the field. Much of the knowledge applied by practicing instructional technologists has been derived from other disciplines including engineering, computer science, cognitive science and communications. While it is not possible to address all of these areas here, a small subset of the knowledge base of Instructional Technology will be examined. The aim of this discussion is to help understand the relationship of Gagné's work to the current state of the knowledge being applied to solve today's instructional design problems, in particular the domains of artificial intelligence, psychology, and learning theories. All of these areas have made a strong impact on the practice of instructional design, including the ways that software is designed and hardware is utilized for instruction.

Gagné's career has coincided with some major revolutions in theoretical descriptions of learning. Beginning with a somewhat behavioral orientation, Gagné has consistently revised one of his major works, *The Conditions of Learning*, to incorporate advances in learning theory as the information processing model of cognition has evolved (Gagné, 1985). The information processing model provides a comprehensive description of how information is acquired and retained in the human mind, as well as how expertise develops. Gagné's instructional design model (Gagné, Briggs, & Wager, 1992) is based on the prevailing view of cognition that assumes thinking involves processing of information within memory structures in the brain. Given this explanation as a basis, Gagné has proposed instructional prescriptions designed to facilitate learning in the various categories of learned capabilities that he has identified (Gagné, 1985; Gagné & Glaser, 1987). According to Gagné, learning some of these skills can be facilitated if instruction is organized hierarchically, so that prerequisite skills are learned in the appropriate order.

Considerable guidance is also provided for direct instruction through Gagné's prescription of events for instruction. He suggests that a particular sequence of events should occur in order to facilitate learning (Gagne, Briggs & Wager, 1992). These events serve to orient the learner to the learning task, focus attention on pertinent information, and elicit performance with guided practice. Whether the instruction is traditional or computer-based, the events are essentially the same (Gagné, Wager & Rojas, 1981). This model for direct instruction is very similar to other models of direct teaching, especially that of Madeline Hunter (Hunter, 1982, 1984).

Much of the theoretical progress made in the area of human information processing has been achieved by modeling with computers the symbolic computation involved in human cognition. As a result, a field of research in computer science has emerged that is concerned with the development of artificial intelligence (Wenger, 1987). Significant progress has been made in vision processing, language processing, knowledge representation and reasoning, knowledge engineering, and intelligent tutoring systems, but we are far from the point where the complete range of human intelligence can be achieved by devices such as computers. One of the major tasks facing researchers in this area is to find ways to represent knowledge in structures that computers can utilize for reasoning. Many of the techniques and procedures utilized for artificial intelligence knowledge acquisition, representation and reasoning can also be employed in the instructional design and development process (Nelson, 1989). Recent activities in Instructional Technology research are taking advantage of the techniques of artificial intelligence, especially knowledge engineering, to streamline the instructional design process and allow more direct participation by subject matter experts (Jonassen & Wilson, 1990; Richey & Nelson, 1996).

Recently, a challenge to the dominant information processing paradigm in psychology has been proposed by those interested in situated cognition and constructivism (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Suchman, 1987). Situated cognition poses a radically different explanation of learning, conceiving it as a largely social phenomenon. Rather than occurring within the mind of the individual, learning is instead described as a characteristic of many social interactions that take place within a framework of participation (Hanks, 1991). Indeed, from this perspective learning requires a rich repertoire of essential actors and participatory relationships beyond those commonly found in education and training as now practiced, emphasizing instead the participation in social groups that is characteristic of learning in a variety of settings and cultures outside of formal education. Situated cognition also proposes a different philosophy of knowledge as it relates to the learning process, suggesting that knowledge is not an internal component of the mind, but rather is a relation between an individual and a social or physical situation (Greeno, 1989).

Constructivism is a parallel movement in psychology that suggests knowledge is constructed by learners in personal ways based on personal experiences (Paris & Byrnes, 1989). What is required for learning from a constructivist perspective is an environment that promotes discovery, reflection, negotiation of meaning among learners, and communication of knowledge between learners (Bednar, Cunningham, Duffy, & Perry, 1990). Instruction from the constructivist perspective should be a self-regulated process engaged in by a learner who is motivated to explore problems and situations. Technology can be employed to provide the kinds of environments appropriate for constructivist learning (Duffy & Jonassen, 1992), and a great deal of recent research and speculation has focused on the design of these learning environments (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; Hannafin, 1992; Jonassen, Peck, Wilson, & Pfeiffer, 1998; Rieber, 1992)

These new conceptions of learning propose viable alternatives to current cognitive theories, and will require new approaches and procedures for the design and development of instruction (Orey & Nelson, 1997; Young, 1993). Instructional design has traditionally focused on the variables and conditions necessary to improve learning in settings that feature intentional learning and direct instruction. While Gagné has not directly addressed the issues of constructivism and situated cognition in his writing, his concern for keeping his instructional theories current is evident in one of his more recent publications. Proposing a new cognitive structure termed "enterprise schema," Gagné and Merrill (1990) attempt to broaden the analysis of content and learning tasks in order to identify "integrative goals" for instruction (see Chapter 6). Others have followed this lead in suggesting that instructional design must consider broader issues than the learning task, such as the environment for learning (Tessmer, 1990), and the context for learning (Tessmer & Richey, 1997). This attention to new developments in learning theory, and the subsequent modification and extension of his own theoretical descriptions is a hallmark of Gagné's work.

One other knowledge base utilized in Instructional Technology that has received little formal study is the personal knowledge and beliefs of practitioners. Little is known about how this knowledge might affect the processes and products of Instructional Technology. Some research has indicated that an instructional designer's expertise greatly influences the kinds of decisions made at various stages of the design and development process (Nelson, 1988; Rowland, 1992). Designers tend to produce solutions for novel problems that are based on similar problems they experienced in the past. The knowledge acquired from previous projects may serve as a template for understanding the current problem, as well as generating solutions for the problem (Goel & Pirolli, 1988). Not only does prior knowledge and experience affect design solutions, but also the belief systems held by instructional designers can influence their practice (Shambaugh & Magliaro, 1997). Beliefs about learning and instruction that have been established through reflection on Gagné's work will probably serve the designer well.

Current Practice

The practice of Instructional Technology employs the knowledge and beliefs discussed above to design, develop, utilize, manage, and evaluate instruction. This practice includes models for designing and developing instruction along with procedures for working with these models. Of course, the current practice of Instructional Technology is influenced by the knowledge sources employed by the practitioner (both theoretical knowledge and life experiences), as well as constrained or enabled by the hardware and software to be employed as part of the instruction.

Design Models: The Design of Computer-Based Instruction

The process of designing computer-based instruction is very similar to the processes recommended by traditional models of instructional design and development that have been practiced for years. In fact, many texts on instructional software design advocate models that can be attributed to the work of Gagné and Briggs (Gagné, Briggs, & Wager, 1992; Briggs, Gustafson, & Tillman, 1991). For example, Allessi and Trollip (1991) recommend a process that includes traditional stages such as needs identification, goal specification, task and content analysis, and sequencing objectives. Hannafin and Peck (1988) organize their design model similarly, as do Soulier (1988), Price (1991), and Flouris (1987). What these models have in common is a concern for a systematic design process that emphasizes learner outcomes as a central element of the planning and authoring process.

Gagné's work, however, has influenced more than just the basic models employed for instructional software design. The application of his Events of Instruction model (see Chapter 4) has been discussed by numerous authors (Jonassen, 1991; Wager, 1981), and has been exemplified in an article by Gagné himself (Gagné, Wager, & Rojas, 1981). The advantage of applying this theory to instructional software design is that most authoring environments are atheoretical, that is, there is some provision for screen design and interaction strategies, but no guidance for incorporating sound instructional principles is provided. Therefore, it is imperative that the designer specify components for the instructional software that are based on design principles such as those suggested by Gagné.

Design Tools: The Automation of Instructional Design and Development

Systematic instructional design and development utilizes a variety of methods and techniques to organize and control a very complicated process, but even so, the process can be very time consuming and costly. Efforts to streamline the instructional design process have focused on the development of knowledge-based tools that assist designers to interpret problems, control design activities, and produce specifications (Richey & Nelson, 1996). Many of these tools employ artificial intelligence techniques to represent in computer systems the kinds of knowledge and reasoning necessary for instructional design. While a variety of approaches have been tested, work in this area tends to fall into one of three categories: individual tools for self-contained design tasks, integrated systems for decision support and process structure, and integrated systems that act as "drafting boards" for the design process.

Knowledge-based tools for instructional design and development activities have been employed for many years, at first as on-line job aids for novice instructional designers in the military (Schulz, 1979; Schulz & Wagner, 1981), then as expert system modules that could be accessed to provide guidance in such design tasks as classification of objectives, needs assessment (Kearsley, 1985), media selection (Gayeski, 1987), and job/task analysis (Hermanns, 1990). A more comprehensive system has been developed by Merrill (Li & Merrill, 1991; Merrill & Li, 1989) using expert systems technology to capture the knowledge and reasoning necessary to make decisions for all aspects of the design process, with special concentration on tools for acquiring and analyzing subject matter content (Jones, Li, & Merrill, 1990). Other researchers are pursuing the development of structured environments for instructional design that do not feature the system-controlled consultation sessions that are common to expert systems

(Gustafson & Reeves, 1990; Munro & Towne, 1992; Russell, 1988). These systems tend to feature open-ended "workbenches" that provide numerous tools for structuring and managing the design process while allowing the designer the flexibility to complete tasks when desired, not under the control of an expert system interface.

Gagné's attitude toward these efforts seemed neutral and cautious during an interview reported in *Educational Technology* (Twitchell, 1991). When asked if building expert systems for instructional design was a reasonable approach to evolving instructional design theory, Gagné expressed concern over the level of complexity already involved in the design process, but agreed to "wait and see what comes out" before forming a final judgment about the technology (Twitchell, 1991, p. 39). Since then, he has been involved in a similar project to "extract" his knowledge of instructional design and represent it in a knowledge-based instructional design system. It remains to be seen whether such systems will be used by practicing designers, as several problems in implementation and utilization have been identified (Locatis & Park, 1992; Gayeski, 1987).

Hardware

An interesting trend has surfaced in the development of hardware utilized for educational applications. The emerging technologies available for education are also converging technologies, that is, most of the newer hardware capabilities are converging on the computer as the central medium. Recent developments in interconnectivity provided by telecommunications networks such as the Internet have opened up countless opportunities for educational activities utilizing the vast information network that has developed around the World Wide Web (Khan, 1997; Reinhart, 1995). Improvements in storage capacity, processing speed, and memory have stimulated the emergence of digital multimedia, including compact disc storage devices and opportunities for two-way interactive learning over telecommunications networks. Advances in the design and construction of input/output devices have spurred the development of virtual reality technologies, allowing users to interact with the computer in high-fidelity simulations of electronic "worlds" that are digitally generated.

As previously noted, Gagné is not an engineer involved in the design and development of this hardware. Nonetheless, his research and theories can still provide considerable guidance in deciding how the available hardware should be used for instruction. First, we must better understand the role of video, audio, and pictorial information in the processes of learning and instruction. Gagné (1986) identified some of the important research questions that need to be addressed with respect to learning from a variety of media, whether the learning is incidental or intentional. Research is needed regarding what outcomes are achieved when people learn from pictures and diagrams, and how pictures (including video) can be designed to make learning more effective.

Second, as multimedia materials become easier and more cost effective to produce, and as computers with multimedia capabilities are becoming common in schools and other institutions, media selection for computer-based instructional software becomes more critical. The question is no longer "Can the computer provide an adequate and cost-effective instructional medium?", but instead, "How can the various media possibilities of which the computer is capable be integrated within this instructional software?" The guidance provided by Gagné's media selection procedures (Reiser & Gagné, 1982) are still applicable to the various components of instructional software, especially when considering the computer's capabilities for simulation and virtual reality.

Even though changes in hardware technologies will continue to provide new opportunities for Instructional Technology, it is still important that hardware capabilities do not "drive" the design of instruction. Too often, the field is influenced by possibilities suggested by new hardware, and a search is begun for an instructional problem for which the hardware solution already exists. As suggested by instructional design models, focus must be placed on the design of effective learning strategies and materials before selecting hardware. But designers must also know what hardware capabilities are available before designing instruction. As Gagné noted: "Hardware itself can only accomplish whatever the human imagination can invent for its use" (Gagné, 1986, p. 14).

Software

Advances in hardware enable, as well as constrain, the kinds of software that can be developed and utilized with any device. As hardware develops, so does the software necessary to utilize the hardware for a variety of purposes. Recent developments in software that make computer hardware more effective for instruction include hypermedia architectures for organization and presentation of information, along with methods for providing adaptive instruction in the form of intelligent tutoring systems. While Gagné has had little if any direct involvement with either of these software technologies, his theories and research continue to provide ample guidance for those interested in the technologies for instructional purposes.

Hypermedia

One of the most exciting developments in the area of "soft" technologies for computer systems has been the advent of hypermedia software architectures. The conceptualization of information "nodes" connected by "links" has significantly changed the ways that people interact with digital information, the ways that authors might organize and present information to people, and the options for designing and developing systems for computer-based instruction. As hypermedia systems have been implemented for educational use, confident predictions of a revolution in learning and instruction have been made (Heller, 1990), but progress is slow and many problems with using hypermedia architectures for instruction still remain unsolved (Marchionini & Shneiderman, 1988).

Hypermedia systems were originally developed out of ideas for information access proposed by Vannevar Bush (1945) and Ted Nelson (1981). Bush envisioned systems where individuals might organize information in personally meaningful ways, storing small amounts of text in files ("nodes" roughly corresponding to a screen of information) that were cross-referenced with electronic links. He developed an early system where a user could "browse" through text by selecting links from one node of information to another (links are typically indicated to the user by underlined or bold-faced words embedded in the text on the computer screen). Bush based his ideas of links on an associationist view of human memory organization, recommending that links be established between concepts that are related in some way in the reader's mind. This concept may provide a way to organize information outside of the mind that reflects how the information is organized in the human brain (Jonassen, 1991; Nelson & Palumbo, 1992).

Ted Nelson took Bush's ideas to another level, suggesting that some day a culture might exist where individuals organize and "publish" their ideas using a hypertext architecture to create a vast "web" of information that can be shared globally (Nelson, 1981). It has taken many years for computer hardware and software to develop to the point where hypermedia systems as envisioned by these early pioneers have become readily available, but the capabilities of current systems have surpassed the dreams and speculations of early proponents. Hypermedia systems are now commonplace, allowing for nodes of information that might include text, pictures, sound and motion video, and for delivery through the Internet.

Many of the hypermedia applications developed for education have focused on the information presentation capabilities of the medium, but hypermedia architectures also allow systems to be designed for knowledge representation and knowledge construction (Nelson & Palumbo, 1992). Hypermedia presentation systems provide databases of information that can be browsed or searched in order to read or view information that is associatively linked.

Knowledge representation systems attempt to make explicit the nature of the relationships between the information contained in the nodes. Graphical browsers, knowledge maps, or links that are visually "coded" to indicate the structural relationships between concepts in the knowledge base are common in these type of systems. Knowledge construction systems support learners in their direct interaction with information, allowing them to author nodes, create links, annotate, or share ideas with others.

Simply allowing learners quick access to information through a learner-controlled, nonlinear organization may not ensure learning (Nelson & Palumbo, 1992). Additional instructional activities and knowledge base structures are needed to help learners acquire the necessary knowledge and skills (Kommers, Grabinger, & Dunlap, 1996; Locatis, Letourneau, & Banvard, 1989). Gagné's conception of learning hierarchies is directly applicable to hypermedia systems designed for instruction. Information organized hierarchically may allow learners to access nodes at elementary levels before moving upward, thereby ensuring that subordinate knowledge and skills are acquired before superordinate. Research suggests that learners who use hypermedia systems that are structured hierarchically tend to navigate initially through the information in systematic ways, rather than in non-linear patterns (Beasley & Waugh, 1997). Attempts to provide appropriate instructional events (Gagné, 1988) and other instructional strategies commonly used for printed text may also improve the instructional capabilities of hypermedia systems.

Intelligent Tutoring Systems

Intelligent tutoring systems have evolved from traditional computer-based instruction, but emphasize different theoretical perspectives and design principles. Intelligent tutoring systems encode knowledge to be used to make instructional decisions as the learner interacts with the system. On the other hand, traditional computer-based instruction encodes instructional decisions made before the learner interacts with the system (Wenger, 1987). Intelligent tutoring systems tend to separate subject matter from teaching method, emphasizing the idea that natural learning occurs through context-based performance. The software is designed to identify student misconceptions and provide appropriate instructional interventions through the interaction of four system components: the interface, the learner model, the expert model, and the pedagogical model (Orey & Nelson, 1993). Through the two-way communication provided by the interface, the learner engages in some activity while the system interprets the activity, passing the results of the interpretation along for diagnosis. By comparing the learner's current knowledge state and actions with the knowledge in the expert model, the intelligent tutoring system ascertains the nature of the learner's error and uses the knowledge in the pedagogical model to make decisions about what, when and how instruction for the learner should proceed.

Gagné has expressed some skepticism of intelligent tutoring systems (Twitchell, 1991). He feels that many interesting ideas are being tested, such as the notion that the knowledge of the learner must be considered in designing instruction, or that the basic difference between novices and experts is the knowledge they possess, or that experts tend to employ problem-specific strategies in problem solving. While all of these knowledge components are typically addressed in the design and development of intelligent tutoring systems, Gagné believes that it is necessary to go beyond merely embedding such knowledge within a computer program. However, he does not specify what additional components should be addressed in intelligent tutoring system research.

Despite his lack of direct participation, Gagné's ideas have had some influence in the area of intelligent tutoring system research. One of the difficult problems for intelligent tutoring systems is to structure a curriculum for each individual learner, and to do so dynamically while the learner is interacting with the software. A comprehensive review of procedures for curriculum planning in intelligent tutoring systems identified several methods for calculating paths through learning hierarchies (Capell & Dannenberg, 1993; Nesbit & Hunka, 1987) that can be directly related to

Gagné's work. But the question remains whether learning is truly facilitated by a hierarchical curriculum. There is evidence that expert knowledge and performance is hierarchically structured (Dunn & Taylor, 1990; Stepich, 1991), but studies comparing instruction organized hierarchically with other organizational strategies have been largely inconclusive (Wedman & Smith, 1989; Yao, 1989).

Conclusions

The impact of technology on various aspects of society, and education in particular, is growing at a rapid pace. It is in this atmosphere of technological dependence that efforts to improve education and instruction continue. Predictions of the future of education within a technological society suggest basic systemic changes will continue as we expand existing communication and information networks, focus on curricular revision and accountability, restructure schools, and explore the implications of new learning theories and instructional methods (Perelman, 1992). The future may also see a continuation of more "superficial" technological changes that expand the utilization of artificial intelligence in education, the development of informal learning environments, and the expansion of information technologies and networks (Heinich, Molenda, Russell & Smaldino, 1999).

In order to meet the needs of subsequent generations of learners, it is necessary to base new developments in Instructional Technology on sound theoretical principles such as those provided by Gagné. This chapter has examined several areas in which Gagné's work has influenced the development and utilization of technology for instruction. Sometimes this was a direct influence brought about by his work in a particular area, and at other times it was an indirect influence based on his theoretical work. We should continue to explore these and other areas where Gagné's ideas might prove beneficial as new technologies emerge and as we devise new uses for existing technologies. But above all, it is necessary to avoid the "technology for technology's sake" mentality, and continue to employ technology as a means to improve and optimize the processes of learning and instruction.

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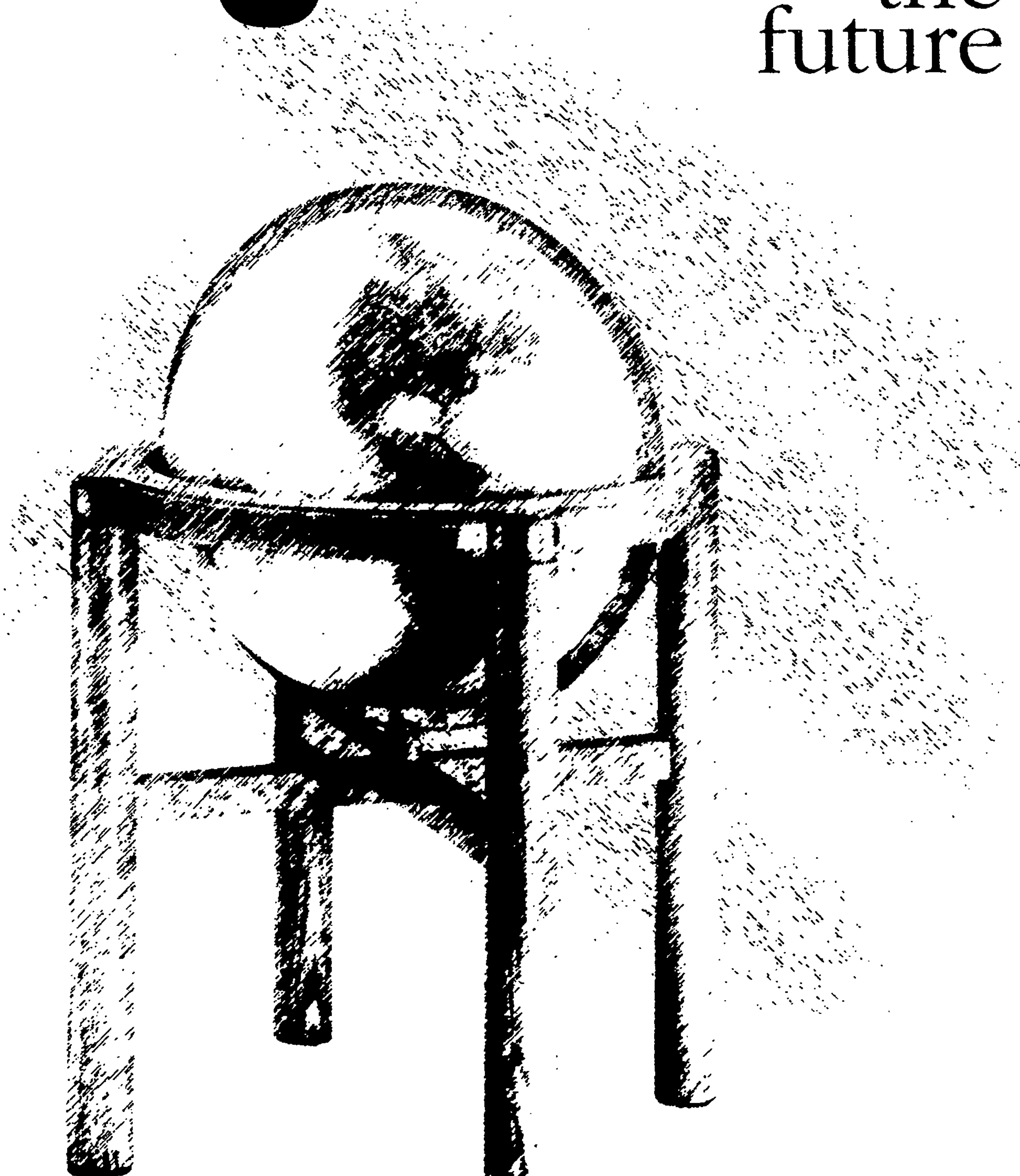
section 3

the future



Chapter 10

The Future Role of Robert M. Gagné In Instructional Design

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Instructional Technology is a field that has grown from two separate knowledge bases and two related areas of practical concern. Its original roots were in the study and construction of visual aids as teaching devices. This line of thinking is consistent with the current fascination with computers and their role in the delivery of instruction. The field's second major line of intellectual heritage emanated from instructional psychology, and provides the bases for many principles of instructional design theory and practice. Gagné has been a central figure in this infusion of psychology into the field, and indeed in the "creation" of the domain of instructional design. Today, the bulk of the research and theory in Instructional Technology is concentrated in the design domain (Seels & Richey, 1994).

Instructional design can be seen in terms of either macro-design procedures which provide overall direction to a design project (typically using instructional systems design principles) or micro-design that involves the design of lessons and instructional strategies which constitute those lessons. Gagné's contributions have been primarily in the development of micro-design principles and procedures. However, his work at the American Institutes for Research in Pittsburgh and at Florida State University tended to involve collaboration with experts in the systematic design of instruction, as well as in the psychology of learning (Briggs, Campeau, Gagné, & May, 1967; Gagné, Briggs, & Wager, 1992; Gagné & Dick, 1983).

Gagné's orientation to design, as summarized in Chapter 6, now serves as the crux of many other design models, such as in Instructional Transaction Theory (Merrill, 1999), Elaboration Theory (Reigeluth & Stein, 1983; Reigeluth, 1999), or the ARCS Model of Motivation Design (Keller, 1987). In each of these models, learning is fundamentally viewed as an internal process that is:

- Dependent upon past learning
- Stimulated and controlled by external events
- Expedited by instruction which varies depending upon the nature of the desired outcome, and
- Precipitated by the use of sequenced instructional strategies that provide motivation, direction, guided practice, feedback, and reinforcement.

These ideas emanate substantially from the work of Robert Gagné.

The principles promoted by Gagné provide not only a theoretical orientation to an instructional design project, but also have prompted a number of design conventions and techniques. For example, designers construct learning hierarchies as a technique by which they can determine the full sequence of content related to a given instructional objective, and the techniques have also been extended to designing and sequencing instructional programs. Designers use the events of instruction as a framework for lesson design, or the Gagné taxonomy of learning tasks to classify the objective of a particular lesson.

In the years since Gagné first began his research, instructional design was "born" as a field and began maturing as a profession, as well as an area of study. In many environments, it is considered a discipline unto itself (Richey, 1986). This development has also been accompanied by an expansion in the various environments in which designers work. Practitioners work in the military, corporate training arenas, the health care industry, the K–12 schools, and higher education. Gagné's ideas are now embedded in each of these worlds of work. In addition, his design principles have been integrated into delivery systems of all types. They are relevant to designers who are producing both stand-up training and computer-based instruction. They are relevant to designers of simulation games and cooperative learning environments.

The key question in this chapter, however, is "To what extent will Gagné's theories *continue* to influence the field as design research expands and as design practice changes in response to new demands and pressures?" While Gagné's dominance has been assumed in the past, this question is not unrealistic in the current climate of growing alternative perspectives of both research and design processes. Today's intellectual climate is subject to many pressures from new theoretical orientations, as well as from on-the-job demands for additional efficiency and effectiveness. These changing pressures and ideological influences may also control the impact of the Gagné design orientation.

Nonetheless, Gagné's influence has been so pervasive (as demonstrated in Chapters 6-9), that it is easy to find traces of Gagné theory even in the most divergent design orientations. The aim of this chapter is not so much to further identify Gagné's imprint on our field in *emerging* design theory and practice, but rather to analyze these trends in an effort to predict the stability and continuing relevance of his theory.

The Continuing Domination of Gagné Doctrines in Design Theory

Previously unvoiced challenges to traditional principles of instructional design theory are now surfacing in the field. To a great extent, these challenges stem from criticism of instructional design's heavy reliance upon general systems theory and conventional learning theory. New learning and instructional theory, especially those positions concerning the role of the learning task, the impact of the learner and learner control, and increased concern with the need for transfer of training, is closely related to Gagné's work. These innovations are presented within the context of constructivism, situated learning, and an even more pronounced emphasis on organizational performance improvement principles. As a whole, they raise the possibility of fairly profound changes in design practice.

The Emerging Tension Between Learner-Centered and Content-Oriented Instruction

Trends in Learner-Centered Instruction

Both the nature of the learning task and the nature of the learner guide instructional design procedures. With respect to the learning task, Gagné's work leads to an analysis of the content so that one can not only determine the sequence of a lesson, but also diagnose the prerequisite skills of the learner. Instructional strategies are also contingent upon the learning task, since they vary depending upon the type of task being addressed. For example, problem-solving tasks are taught differently from concept formation tasks. While learner characteristics are clearly important, traditionally, instructional design procedures have been controlled more by the *material* to be taught than by the *persons* receiving the instruction. This position is totally compatible with the objectives-oriented stance of instructional systems design models. However, to many it is also an outdated vestige of behavioral learning theory.

Currently, there are trends toward a change in this stance with much of the new theoretical thinking focusing more centrally on the learner, with content taking a somewhat secondary role (Richey, 1993). This is most evident in constructivist theory that posits that meaning and reality are functions of individual interpretation (Jonassen, 1991; Lebow, 1993), and learning itself is a process...

> ... in which the learner is building an internal representation of knowledge.
>
> ... This representation is constantly open to change, its structure and linkages forming the foundation to which other knowledge structures are appended. Learning is an active process in which meaning is developed on the basis of experience (Bednar, Cunningham, Duffy, & Perry, 1992, p. 21).

Central to constructivism in its most extreme form is the rejection of the notion of an objective reality and the role of external events (i.e., external conditions of learning) as ways of promoting a common reality for a group of people (Duffy & Cunningham, 1996). In other words, the emphasis on an individual's internal processing of information is completely dominant. The learner and learning processes control, and even shape, the learning task.

In spite of the growing popularity of constructivist principles, many designers are uncomfortable with extreme constructivist positions. Dick's (1992) comments in this regard are noteworthy. He observes that educational interventions that are truly constructivist must necessarily provide the learner with almost total control of the instructional process, *including* the selection of objectives and learning activities. This is less because of an adherence to laissez-faire philosophy than it is to a belief that pre-designed instruction is meaningless since two individuals will seldom have the same interpretation or understanding of a particular event. This position minimizes the role of structured instructional activities, in favor of a more tutorial model of instructional facilitation. Merrill (1992) also argues against extreme constructivism by pointing out that while learners develop their own internal mental models in most instructional situations, they nonetheless do respond to and interact with abstractions and mental models of others. There is a functional, objective core of knowledge that can easily co-exist with individual interpretations and opinions of the knowledge.

Questions regarding the dominance of content are not confined, however, to constructivists. Many involved in design and development of instruction using the new and emerging technologies have also come to question traditional practice. Hannafin (1992) argues that traditional instructional design theory and models are most effective with "highly prescribed, objective outcomes and the organization of to-be-learned lesson content, not the largely unique and individual organization of *knowledge*" (p. 50). Instruction controlled by these pre-defined objectives then tends to be seen as only the transmission of knowledge, rather than the facilitation of learning. Kember and Murphy (1990) voice concerns that the product of such instruction is only surface, rather than deep learning. It is learning that is less likely to be transferred and used by the learner in new situations.

It is predictable that constructivists and technology developers would find common ground in these arguments. The new technologies can facilitate levels of learner control previously unattainable. The technologies can give learners instant access to information, and the ability to link information. The technologies allow totally adaptable, interactive, and less structured designs and learning environments than were typical using traditional design orientations (Hannafin, 1992). Here the content becomes *part* of the learning environment, but the learner is more dominant.

Learner-Centered Design and Gagné

The learner-centered advocates, even those who espouse a more extreme position, do not have theoretical bases that are totally incompatible with

Gagné's theory. He stresses the importance of prior knowledge and experience, self-regulated learning strategies, and learner motivation. However, there is a different perspective in the Gagné orientation. While Gagné uses learner characteristics as one basis of strategy selection, the pertinent learner considerations tend to relate to the cognitive processing of information—the nature and capacity of the learner's memory storage and processing skills, qualities that affect sensory perception, and attitudes that directly impinge on learning. These factors shape one's ability and motivation to achieve a given type of learning outcome. They define the learners' cognitive capabilities, prerequisite content knowledge, and interest in a particular topic, and become central to the design of those external conditions that promote learning. Learner characteristics, however, are critical to Gagné's theory primarily in the extent to which they are related to *pre-defined* learning objectives.

Learner involvement (as opposed to learner control) is also a critical aspect of Gagné's work, but learners' participation in the instructional process entails more than simply being engaged in a series of activities, the external performance aspect of instruction. Participation and activity also refer to internal involvement in the perception, storage, and retrieval of information. This is the core of Gagné's cognitive orientation, and the Events of Instruction are designed to promote internal, as well as external activities.

Current advocates of learner-centered instruction present arguments that are multi-faceted, including debates on at least two aspects of the problem:

- Who controls the instructional process, and what is the nature of such control? and
- Which learner characteristics influence the selection and design of instructional strategies and how they should be addressed?

With respect to the first question, Gagné seems to suggest that the designer (or the instructor) has fundamental control of *instructional* processes that are external events, even though individuals always control their own *learning* processes, which are internal events. Superior design of instruction can facilitate learning efficiency, instructional effectiveness, transfer of training, and interest. In these respects then, the designer also exercises a certain amount of control by structuring the external conditions according to research-based principles in a manner that will facilitate internal learning and information processing. Learners and designer/instructors then share control of the teaching/learning process.

Although seldom framed in these terms, the issues surrounding control of instruction seem to have much to do with the type and extent of individualization that is desirable in a teaching/learning environment. Instructional technologists, in spite of the many interpretations of the term have always valued individualized instruction. Fundamentally, individualized instruction involves varying the teaching/learning procedures for each student. These variations occur by making different instructional decisions for different students. These decisions include:

- What and how much should one learn?
- When and where should one learn?
- What resources should one use to learn?
- How does one know when learning has occurred or when it has not?

The extent of individualization depends upon the number of decisions made for individuals as opposed for the class as a whole, and the extent to which learners assume control of the decisions regarding their own instruction. For example, an individualized setting may only involve self-pacing of instruction by the students with the content, materials, and testing procedures prescribed by the instructor. On the other hand, a program may be totally individualized with learners making all of their own decisions, and instructors serving as facilitators. Technologically-based delivery systems clearly expedite learner control. For example, most hypertext environments at the least allow students to control content selection, sequencing, and pacing.

Constructivists and many of those involved in using the new technologies to their fullest advantage, tend to advocate more total individualization. Such instruction is not necessarily incompatible with Gagné's principles of learning. Moreover, the compatibility is not dependent upon whether there is a structured or flexible approach to the management of its delivery. Learners can assume a major part of the control of the instruction, and the process can still be perfectly consistent with Gagné's theory. The critical factor seems to be whether the design of this instruction has been grounded in an analysis of the subject matter and the learner prerequisites, not on whether students are involved in collaborative, active learning of highly relevant content.

In some respects, the second aspect of the learner-centered issue is more interesting—the most critical learner characteristics. Instructional design rooted in a content emphasis, as opposed to a learner emphasis, tends to highlight learner traits that are related in some way to the subject matter of the lesson, including:

- Prerequisite skills
- Background experiences which enhance prerequisites and/or interest in the topic of the lesson, or
- The learner's proficiency in those cognitive strategies required to master the content.

Designers are now considering other learner characteristics as well. For example, Richey (1992) has shown the direct impact on learning of other learner characteristics that are not content-related. With respect to adult learning in employee training environments, pertinent factors include learner attitudes toward the instructional delivery system and the organization delivering the training, the previous training experiences of learners, and their work experience. These learner attitudes and background experiences seem to predict not only the extent to which objectives are achieved during training, but also the extent of transfer. Other characteristics currently being studied include feminist thinking (Gilligan, 1982; Canada & Brusca, 1991) and other aspects of a person's cultural background.

It is possible for one to argue that these characteristics shape the cognitive strategies that a learner uses to address a particular piece of instructional content and, as such, are still within the Gagné tradition. Nonetheless, they do represent a line of thinking which, even though logically connected to Gagné's previous work, is suggesting new design procedures and emphases. It is one, however, which is consistent with Gagné's past thinking.

The Emerging Role of Context in Instructional Design

Theory Trends in Context-Centered Instruction

Another area of current theoretical expansion concerns the impact of context upon the teaching and learning process. Of interest, is not only the immediate teaching context, but also the pre-instructional (or orienting) context and the post-instructional (or transfer) contexts in which learners live and work (Richey, 1993; Richey & Tessmer, 1995; Tessmer & Richey, 1997).

This trend of looking to contextual variables as predictors of learning effectiveness has emerged with the concurrent influence of performance technology, the quality movement, situated learning, systemic design, and once again, constructivism. The commonalty among these divergent theories and movements is an interest in "meaningful" instruction, meaningful to the learner and meaningful to the society that expects to be improved as a result of an educated populace. In the past, such "meaning" has had important implications for the transfer of training from educational environments to real-life behavior. Today, it also has implications for organizational development and quality improvement.

Most instructional design procedures and principles are typically seen as being applicable to all settings. In spite of this, new instructional systems design procedural models are frequently developed in an effort to respond to the seemingly unique aspects of a given situation. This emphasis on situation-specific procedures is complemented by the ever increasing demands that education and training programs serve as quality improvement vehicles and solve specific organizational problems. Contextualization also reflects efforts to create motivating, relevant instruction. While this latter goal is not new, the pressures for intrinsically relevant instruction are increasing with the new emphases on adult education and training and the expectations of children and adolescents reared on action-oriented television. Finally, these events coincide with situated learning and constructivist emphases on "anchoring" instructional activities into meaningful contexts as a means for promoting long-term retention, understanding, and transfer of training. The issue is then an outgrowth of societal changes, as well as new theoretical biases.

The emphasis on context and environment is not unrelated to the learner-centered design thrust, since context is typically a matter of perceptions made by learners in light of their background experiences. Moreover, context emphases also tend to expand the number of factors addressed by designers, sometimes at the expense of instructional content considerations.

Contextualization is typically achieved not only through the topics of instruction, but also through the selection of examples and the nature of the practice exercises. Topics can be those that are currently issues in a particular setting. Examples can be drawn from the social or work culture of the students. Practice can be provided using what Brown, Collins, and Duguid (1989) would call authentic activities. Authenticism involves "ordinary practices of the culture" (p. 34), as opposed to hybrid activities that are more reflective of the education and training culture rather than the "real world." Decontextualized environments, therefore, are not only created through the use of verbal abstractions, but also through the use of examples and practice activities that are not reflective of the daily situations encountered by the learners. One can also create context-rich instruction by using problems, examples, and practice activities involving multiple contexts. In this way, instruction seems realistic, even though it is not "anchored" in a given context. This is not the typical approach, however, in many of the newer approaches to context in instruction.

Current emphases on context have the potential of changing design procedures by not only expanding the needs assessment, evaluation, and systems maintenance phases, but also by altering the nature of the instructional strategies themselves. The ultimate goal is instruction that is less abstract, more applied, and more responsive to external realities than had previously been the case.

Context-Centered Design and Gagné

Streibel (1991) summarizes the fundamental difference, in his opinion, between Gagné's theory of instruction and that of situated learning with respect to contextual issues. He sees environmental factors in the Gagné tradition as playing the role of triggering stimuli in a teaching/learning situation, rather than serving as *causes* of behavior. While this characterization may be debatable, the point is well made that context is not as central in the Gagné theory as it is in many current orientations, and the question at hand involves the extent of this deviation. This issue can be analyzed in terms of the implications of context for transfer of training as well as long-term retention—elements that are not unrelated and need to be considered together.

Transfer of training, from Gagné's perspective, is a function of the extent to which a learner has:

- The required prerequisite knowledge and skills
- The ability to recall prior learning, and
- Developed those cognitive strategies appropriate for the task.

The first is a function of content and background, rather than contextual elements of the instruction. The latter two elements, however, are impacted by context. The ability to recall needed prior le ing is a function, in part, of whether the material to be recalled was originally presented within a meaningful contextual framework. If so, it is far easier to recall. Moreover, the contextual anchoring of past instruction in a variety of novel problem-solving tasks not only enhances meaning, but also develops cognitive strategies used in problem solving and transfer of training. Gagne, therefore, tends to advocate context-rich instruction by systematically using alternative contexts for practice, rather than emphasizing the dimensions of only one environment.

What is more likely to strengthen transfer, generalization, or context-embedded instruction? Clark and Voogel (1985) conclude, "the extent of transfer is determined, in part, by the amount of decontextualization achieved during instruction" (p. 119) but that the issue is also dependent upon the nature of the learning task and the type of transfer anticipated. Procedural knowledge is more conducive to near transfer (i.e. transfer of skills to situations that are similar to those in which the instruction occurred), while concepts and principles are more appropriate for far, or more generalized, transfer situations. Moreover, Clark and Voogel (1985) assert that the two types of transfer are *not* compatible; one is typically emphasized at the expense of the other, even though all transfer is highly dependent upon learner abilities. In this vein, Gagné would likely assert that even though putting instruction into a meaningful context is important, instruction that is dominated by examples from real-life situations is not necessarily in the best position to promote the process of *far* transfer. This point, which has been introduced by Fields in Chapter 7, is one important part of the discussion of differences between Gagné and the advocates of highly context-centered instruction.

Perkins and Salomon (1989) in essence have discussed the same issue, but in terms of the dichotomy between the roles of general strategic knowledge (i.e. decontexualized) and specialized domain knowledge (i.e. contextualized) as predictors of effective problem solving. They conclude that transfer is a highly specific phenomenon and while all specific applications need to consider contextual factors, there is a need to have an "intimate intermingling of generality and context-specificity in instruction" (p. 24). This seems not so very different from Gagné's position of embedding context within the instructional strategies, even though the ultimate goal is to facilitate far transfer.

There is a second aspect of Gagné's work and orientation that needs to be considered when discussing the role of context in promoting both transfer of training and long-term retention—namely, the role of the enterprise schema (see Chapter 5). An enterprise is a complex *purposive* performance involving multiple, related instructional goals. It is a higher level goal than is frequently used in many education and training programs. An enterprise is represented in one's memory by a schema that relates these larger goals (typically presented as a realistic application task) to their prerequisite skills and knowledge. The schema is a mental model that serves as the basis for retention and retrieval, as well as transfer.

The emphasis on integrated instructional goals corresponds with an emphasis on purposive, relevant instruction. While such instruction is designed with transfer in mind, it may not be authentic in the same sense promoted by advocates of situated cognition that seems to view learning as more of an enculturation process. The notions of integrated goals and enterprise schema tend to relate more to *generalized* transfer and a de-emphasis of declarative and procedural learning as an end unto itself. While Gagné would undoubtedly use contextualized examples and practice activities, it is unlikely that he would advocate always rooting instruction in a *single*, even though relevant, context. The most useful enterprise schema is somewhat generic—applicable to a variety of specific enterprises in which one might become engaged. Of course, much instruction, especially that of a training nature, is oriented only toward specific performance-oriented objectives that are more conducive to near transfer, and these situations often demand strategies which utilize a given context.

In summary, Gagné's orientation to context is not totally incompatible with current thinking insofar as it stems from a cognitive orientation. Gagné continues to strive for instruction that primarily addresses higher levels of learning and aspires to far reaching transfer as opposed to specific applications of content. Effective instruction is relevant to learners' needs as well as being appropriate to their skill levels, and shows application in a variety of contexts rather than being "anchored" in only one environment. While procedural knowledge relates to more specific uses, the goal, nonetheless, is to use such knowledge in combination with other skills and knowledge for creative problem solving. Ultimately, Gagné's design theory is generic in nature. It is theory that is applicable to all contexts, all types of content, and all types of learners.

The Stability of the Gagné Orientation to Theory

A clear trend in design theory over the past fifty years has been its continual expansion. There is more research. There is more theory construction. Just as Gagné responded to the issues that were critical during his most productive years, today's scholars are responding to a new set of concerns. While it is evident that the new theorizing is sometimes charting new waters, for the most part new theory is not antithetical to the old and, it continues to build upon Gagné's foundational work. It is likely that Gagné's *primary* positions will remain current to the extent that:

- Cognitive learning principles continue to be accepted
- Design continues to be viewed as a generic activity, and
- Instructional content and strategies continue to be pre-specified and analyzed.

There are now alternatives to each of these perspectives that present radically new design orientations. Their acceptance as more mainstream theory could modify Gagné's impact on future theory development.

The Continuing Domination of Gagné Doctrines in Design Practice

As with theory, the world of design *practice* is also undergoing changes that were previously unanticipated. These changes are, on the whole, reactions to demands for increased design efficiency. Such concerns are especially reflected in current efforts to enhance the traditional instructional systems design models and to reduce design cycle time.

In the preface to the first edition of *The Conditions of Learning* (1965) Gagné indicated that the impetus for this book was to explain "what is known about the process of learning that can be put to use in designing better education" (p. v). This reflects the fundamentally practical nature of instructional design. From one edition to the next, *The Conditions of Learning* became increasingly more practice oriented, and the final edition included four chapters describing specific design and analysis procedures and techniques. His last examination of the conditions of learning was a full exploration of their applicability to modern training environments (Gagné & Medsker, 1996). The question now is basically the same as was posed with respect to his theoretical contributions. Will Gagné's design and development techniques continue to provide direction for the typical practitioner?

In the past, much of Gagné's direction for practice has related to techniques for varying designs in terms of the type of learning task, for using learning hierarchies as a pre-design content analysis tool, and for using the events of instruction as a guide for the design of lessons and the selection of instructional strategies. Clearly these tactics are bi-products of Gagné design theory. While their continued use by the typical practitioner is dependent upon the stability of this underlying theory, such use is also greatly affected by the realities of the everyday world of work.

The Continuing Dominance of Conditions and Outcomes-Based Design

Gagné's contributions to instructional design relate to the premise that learning is brought about by arranging different instructional conditions for different types of learning tasks. Gagné has identified five different domains of learning outcomes, and has suggested varying conditions that are likely to lead to a learner achieving each of these types of goals. (These have been discussed in Chapter 3.) This approach is foundational to most instructional design models and is, by and large, still dominant among current designers who have been formally trained in the field.

While there are currently more advocates of alternative design positions than has previously been the case, this principle seems to be essentially unchallenged by practicing designers. It is not that other instructional foundations have not been suggested, such as the developmental level of the learner, or the use of reinforcement. While Gagné's conditions of learning recognize the role of such elements, the basic principle remains—instruction should vary depending upon what is to be learned.

Constructivists who do not accept this assumption voice the only major dissention to this position .....

> Indeed, from a constructivist viewpoint it is not possible to isolate units of information or make a priori assumptions of how the information will be used. Facts are not simply facts to be remembered in isolation (Bednar et al., 1992, p. 23).

Gagné (as have most instructional designers) has often noted the futility of teaching isolated facts, even though he would nonetheless argue that such content could be classified. It is far more common today for the Gagné position to be supported with respect to this issue, and there is no indication that his basic premise will not remain essentially in tact. Other elements of design practice according to Gagné, however, are to some extent more debatable, even though they too are prevalent among practitioners

The Continuing Dominance of Pre-Design Analysis

Gagné's emphasis on pre-design content analysis coincides with the tenets of general systems theory. The use of the learning hierarchy tool facilitates such analysis as well as the identification of necessary learner prerequisites. Today there are two seemingly opposing trends. The first is to expand the analysis stage to accommodate a wider range of design variables in an effort to promote transfer of training (Richey, 1995). The second is a recognition that many expert designers use other methods that do not depend upon such analysis (Tripp, 1994). Both trends are occurring in the midst of extreme pressure, especially in the world of business, to reduce the design cycle time.

Before predicting the continuing influence of Gagné with respect to pre-design analysis, it is important to try to do justice to his position. With respect to the use of analysis and the construction of learning hierarchies, Gagné has cautioned against rigid use of the technique. For example, he recognizes that a learning hierarchy is not necessarily the sequence by which an *individual* learner will acquire a particular capability, rather it is the most probable route to transfer of training for most people. He also cautions against emphasizing verbal knowledge in a hierarchy at the expense of the underlying intellectual skills. (See Gagné's full explanations of these points in his 1968 article "Learning Hierarchies" in Chapter 2.)

These arguments (made more than 30 years ago) may anticipate, at least in part, current analysis trends. The expansion of the analysis phase today represents not only the increased attention being given to learner characteristics and context, but also a new adherence to designing instruction focused upon larger content units. This latter move is, of course, consistent with Gagné and Merrill's advocacy of integrated goals as well as Gagné's initial position favoring hierarchies that focus on larger intellectual skills rather than discrete pieces of knowledge. The increased use of analysis is a direct extension of Gagné thinking, even though there may be some debate as to the legitimate focus of such analytic activity.

On the other hand, the findings of recent designer decision-making research draw a picture of expert designers working in a far less structured manner, responding spontaneously to situations which "trigger opportunistic excursions that yield unexpected insights into the problem" (Tripp, 1994, p. 117). However, Tripp also cites other research that shows designers using a *combination* of systematic analysis and opportunistic tactics. While Gagné has not specifically addressed this topic, it seems likely that he would support the latter approach.

Most designers today are under great pressure to produce a product in a shorter period of time than one would think realistic. While they know those procedures that are "textbook perfect," they face daily demands to take shortcuts. The first steps to be slashed typically relate to evaluation and a detailed analysis of both content and needs. However, many designers are seeking ways to adhere to the time-proven methods and still be realistic in a business sense. Rather than sacrificing pre-design analysis standards, one salvation may be the use of computer-based design tools. Those tools that relate to content analysis, however, are based for the most part on Gagné techniques. Gustafson and Reeves (1990), Merrill, Li, and Jones (1990) completed early work in this area. Spector, in Chapter 8, describes other related work.

Another current effort to increase the efficiency, as well as the effectiveness, of the typical design task involves the use of rapid prototyping. Tripp and Bichelmeyer (1990) describe this methodology as one in which "after a succinct statement of needs and objectives, research and development are conducted as parallel processes that create prototypes, which are then tested and which may or may not evolve into a final product" (p. 35). As with the use of computer-based design, rapid prototyping builds upon traditional design practice although the stages are not linear in nature (Jones, Li, & Merrill, 1992). Content analysis in the Gagné tradition, however, is central to the early rapid prototyping stages in a similar fashion to its use in conventional systematic design. Nelson, in Chapter 9, has introduced both of these applications of technology to Gagné's work. He demonstrates the ability of traditional practice tools, many of which were introduced by Gagné, to transcend the changes being interjected in the new design work environments.

The Continuing Dominance of the Events of Instruction

Another important tool for designers has been the use of Gagné's Events of Instruction. The Events serve as a conceptual model for the design of lessons, the selection of instructional strategies, and the sequencing of instruction. In essence the Events summarize much of the key research related to instruction, including factors such as motivation, perception, feedback, reinforcement, individual differences, retention, and transfer. They provide a framework for creating those external conditions that promote learning.

Inherent in the Events is the notion of designer control of instructional options. While this is at odds with some constructivist theory, it is nonetheless consistent with the vast majority of the design practice in education and training environments today. The Events have been used regardless of the delivery medium, encompassing everything from stand-up training to computer-based instruction. For many expert designers the Events are now an internalized model that guides their work on a seemingly intuitive level. This is reflective of Duffy and Jonassen's (1991) assertion that "while instructional designers typically may not have the time or support to explicitly apply a theory of learning during a design or development task, the theory is nonetheless an integral part of the instruction that is produced" (p. 7).

While some may disagree on the particular strategy that is best for a given situation, there is little disagreement with the Events of Instruction themselves because they summarize key *stages* in the instructional process which have been repeatedly validated in the research literature. For example, conscious learning in a formal instructional environment requires attending to the topic and guidance, as well as reinforcement. While there are various strategies for accomplishing these tasks, one must be selected. As such, the general framework provided by the Events remains constant.

To a great extent the Events framework is likely to remain useful even in situations which have student-controlled sequencing of learning activities, as is more frequently the case in computer-based instruction. This is because the instructional events still need to be programmed and available for learner use. While it is likely that multiple strategies and activities will be incorporated into a particular piece of instruction, each of the various functions of instruction (as suggested by the Events model) must still be accommodated. Such structure is as appropriate for designing individualized environments, as it has proven to be for the design of teacher-directed instruction.

The Stability of Gagné's Orientation to Practice

Gagné has consistently argued that instructional design practice should be based upon what we know about human learning. This position is seemingly axiomatic. Since it is unclear to most that the field currently has a completely accurate view of all human learning, it is possible that the stability of Gagné's orientation to design practice is assured because of our tendency to combine ideas from a variety of plausible explanations of the learning process.

However, practice techniques, even when based upon complex theory, often tend to be streamlined and simplified. Perhaps this accounts for the fact that there has been less debate related to design practice than theory, and for many of Gagné's practice techniques to remain current even in the midst of great theoretical debate. Bednar, et al. (1992) are not satisfied with the field's tendency to create a patchwork collection of tools and techniques that have been abstracted from different (and often conflicting) theories being used in a given design project. They argue that this eclectic approach does *not* produce the most effective instruction.

In any case, Gagné's basic orientation has become ensconced in design tradition, even *with* the emergence of new theory. Most trained instructional designers select their design focus depending upon the nature of the learning task, and are likely to continue this practice. Most will continue to conduct some sort of pre-design content analysis as a precursor to sequencing and identification of prerequisite skills—even if they do not *overtly* use the learning hierarchy tool. Most will continue to select instructional strategies based upon a general Events of Instruction framework—even if it is internalized and not consciously used. To some extent this begs the question of whether *expert* designers who demonstrate alternative design decision-making patterns are really deviating from the Gagné tradition or are still using the same principles.

If major deviations from the Gagné orientation do occur, it is typically because time limitations are posing barriers to their use. Such pressures are leading to a reexamination of design practice. However, most expert designers are increasing design efficiency using the same basic orientation, rather than making a sharp break with past tradition. Dick (1993) calls this process the *enhancement* of the instructional systems design process. Even time saving design models such as Tessmer and Wedman's (1990) Layers of Necessity approach, which suggests a way to streamline the process given the demands of a given situation, does not radically change the fundamental orientation to design. Therefore, the basic Gagné approach will continue to provide direction to the field, even with changes and advancements in design tools and techniques.

Conclusion

Robert Gagné has substantially shaped a new field of instructional design during his career as a psychologist. He made enormous contributions and had an enormous impact as both a researcher and a practitioner. While design has been called a "linking science," Gagné himself has also served a linking role throughout his career. He has linked the heyday of behavioral psychology with the dominance of cognitive psychology. He has linked the field's emphasis on designing educational programs for children with an emphasis on designing training programs for adults in the military and in business settings. He has linked basic learning research to applied educational research. He has linked theory to practice.

In his more than 50 years of active work, Gagné explored the complex processes of learning and instruction, and explained them to generations of designers in a simple, understandable way. In the process he has demonstrated his true genius. Gagné's work was spurred on by important social events that highlighted its importance and need for the general public rather than only a small intellectual community. There was an urgent need for efficient, effective training early in World War II. The Sputnik crisis in the 1950s highlighted the need for American schools to reinforce mathematics and science education. American corporations looked to education and training as an avenue to retool their workforces and to meet foreign competition. His research and the successful application of this research in a variety of settings provided evidence of its relevance and practicality. In addition, its legitimacy was rooted in scientific authority and superior academic credentials.

Gagné's ideas were part of other prominent intellectual movements over the years, including behavioral and cognitive psychology, general systems theory, and the early explorations into the nature of instructional theory. He was a contemporary of other giants of the world of education scholarship, including persons such as Benjamin Bloom, Jerome Bruner, John Carroll, Robert Glaser, and Ralph Tyler. In retrospect, there was a social and intellectual climate in the United States that was conducive to the proliferation and acceptance of Gagné's work.

Today, the field of instructional design has grown. It has many areas of specialization, many delivery options, and many alternative theoretical perspectives that command considerable support. Furthermore, there are far more people involved in the field. This growth in itself is testament to Gagné's work. However, this more complex environment may greatly reduce the possibilities of one person alone exercising the same over-arching dominance of a Robert Gagné.

Yet Gagné's influence is surely attributed to more than "being in the right place at the right time." Ultimately, his influence is a product of the power of his ideas. His influence is a product of those seemingly simple principles, which most of us are still re-examining. We continue to find that Gagné's principles provide new meaning and new direction. Perhaps his influence will be even more important though, as designers evaluate his contributions and build upon them, devising new approaches and theory to solve new problems. Is that not the power of an intellectual legacy?

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Appendix A

1982 American Psychological Association Distinguished Scientific Award for the Applications of Psychology[13]

The Distinguished Scientific Award for the Applications of Psychology is presented to a person who, in the opinion of the Committee on Scientific Awards, has made the most distinguished or empirical advance(s) in understanding or ameliorating an important practical problem. In accordance with established custom, the award winner will present an address on some phase of his scientific work at the 1983 convention. This year's winner, Robert M. Gagné, was presented with a check for $1,000 and a citation of his contribution. The award was presented by Edwin A. Fleishman, chair of the Committee on Scientific Awards. Other members of the committee are John Garcia. Donna Gelfand, Marcia Johnson, Edward E. Jones, and G. Terence Wilson. The winners since the establishment of the award are listed below:

1973 Conrad L. Kraft
1974 Gerald S. Lesser, Edward L. Palmer
1975 Nathan H. Azrin
1976 Fred S. Keller
1977 Starke R. Hathaway
1978 Alphonse Chapanis
1979 Joseph Wolpe
1980 Edwin A. Fleishman
1981 Anne Anastasi
1982 Robert M. Gagné

[13] We are indebted to the APA for their permission to reprint the text of the Scientific Award.

Robert M. Gagné

Citation

For outstanding and influential work in the field of human learning. His particular genius is the ease with which he moves between research and development, enriching both. Through his work in complex skills training, he has deepened our knowledge of transfer of training, problem solving, techniques of task analysis, and instructional systems. His research on the acquisition of knowledge led to a theory of learning hierarchies that stimulated research on the learning of subject matter and the design of curricula. His book, *The Conditions of Learning*, a brilliantly clear exposition of various kinds of human learning as they relate to methods of instruction, sparked new interest in the contributions of psychology to education.

Biography

Influenced by his reading of popular works, Robert Gagné decided in high school that he wanted to study psychology and perhaps become a psychologist. The high school in question was in North Andover, Massachusetts, a town that included farms and open country as well as suburban housing for the neighboring textile city of Lawrence. Many of his classmates were the sons and daughters of immigrants from Europe, young people who strove to put aside their ethnic origins and become full-fledged Americans; in this they usually succeeded.

A scholarship offer from Yale University sent Gagné to that institution, where he found continuing provision for both scholarships and part-time work in subsequent undergraduate years. The introductory course in psychology, despite fine instructors, raised doubts about his choice of such a pesky subject. Advanced courses, however, were more satisfying. As a psychology major, he was fortunate to have Edward S. Robinson as an undergraduate advisor. Although Professor Robinson met an untimely death during Gagné's final year at Yale, his influence as a teacher and his advice regarding graduate work ir psychology continued to exert their effects.

Brown University was the site of Gagné's graduate study. As people of his generation often remind themselves, most graduate students of that day were unmarried. As a consequence, they spent almost all of their waking hours in the psychology building. In that setting, they had the opportunity for frequent interaction with an outstanding faculty, most of whom also spent a great deal of time "in the laboratory." The department was headed by Walter S. Hunter, a behaviorist of the old school, much of whose research was devoted to a study of cognitive processes ("the symbolic process"). Gagné's graduate advisor was Clarence H. Graham, whose work on visual mechanisms is widely known. Graham was interested in finding out whether precise mathematical formulations of the sort common in studies of vision could be employed in the field of learning. Following some initial collaborative work with Graham on this problem, using white rats on a runway, Gagné continued studies of the "conditioned operant response" under various incentive conditions, and these were collected as parts of his Ph.D. thesis.

His first job as a college instructor came in 1940 at Connecticut College for Women. He made initial preparations to study the learning of humans rather than of white rats, but these activities were interrupted by the circumstance of a low draft number and induction into the Army of the United States for a period of military training. The expected limits of that period were, of course, abandoned with the formal declaration of war in December 1941.

The period of World War II was an interesting and challenging one for many psychologists. Following a stint of basic training, Gagné reported for duty to Psychological Research Unit No. 1, Maxwell Field, Alabama. This was one of three units initially established as part of the Aviation Psychology Program, whose mission was to administer and score batteries of aptitude tests to select and classify aviation cadets who were to become crews of combat aircraft (pilots, navigators, bombardiers, gunners). At Maxwell Field, the food was good, the living quarters never quite good enough, and the work of testing and scoring continually interesting.

During the next year, Gagné attended Officer Candidate School at Miami Beach. Following his commissioning as a second lieutenant, he was assigned briefly to a headquarters at Fort Worth, Texas, and then to the School of Aviation Medicine, Randolph Field, Texas. Here, in a section headed by Arthur W. Melton, he participated in the development, inspection, and technical description of the psychomotor tests used in aircrew classification. A later assignment was to the Perceptual Film Research Unit, Santa Ana Army Air Base, headed by James J. Gibson, which was engaged in developing film tests of perceptual abilities. Gagné's final Army assignment, short in length, was to the Psychology Branch, Aero Medical Laboratory, Wright Field. Under Paul M. Fitts' leadership this organization initiated the study of what came to be called human engineering.

After holding a temporary faculty position at Pennsylvania State University, Gagné returned to Connecticut College. During this period he carried out studies of learning and transfer of training in multidiscrimination motor tasks, under a grant from the Navy Special Devices Center. In 1949 he accepted an offer conveyed by Arthur Melton to join a U.S. Air Force organization called the Human Resources Research Center, which later became the Air Force Personnel and Training Research Center. His initial position was research director of the Perceptual and Motor Skills Laboratory, an organization whose mission included basic research in these areas as related to military training. The influence of this experience was reflected in a textbook having a "human performance" flavor, co-authored with Edwin A. Fleishman.

Later he became technical director of the Maintenance Laboratory at Lowry Air Force Base, Colorado, an organization engaged in research on the training of electronic maintenance personnel and associated specialties. An unusually talented group of research psychologists was assembled at this laboratory, and most have remained outstanding investigators over the years down to the present. Besides conducting training research, the laboratory played a leading role in the development of a technology for forecasting personnel and training requirements for newly developed weapons systems; the basic elements of this technology have remained in continuing use by the U.S. Air Force. Largely because of his association with a stimulating group of research scientists during eight years of civilian service with the Air Force, Gagné looks upon this period as one of peak enjoyment in his profession.

In 1958 Gagné returned to academic life as a professor of psychology at Princeton University. In this period, his research included studies of problem solving and the learning of mathematic skills. Partly in response to a prevailing trend of the time, his interest in research shifted toward the learning of school subjects. He carried out collaborative studies with the University of Maryland Mathematics Project and participated in the development of the program in elementary science, "Science-A Process Approach," a project sponsored by the American Association for the Advancement of Science. During this period Gagné conducted studies of intellectual skills and their prerequisites, leading to the formulation of the notion of the "learning hierarchy" as it applies to such skills.

Continuing to be attracted toward research with an applied orientation, in 1962 he joined the American Institutes for Research, whose president was John C. Flanagan. This organization was heavily engaged in research on training, the assessment of human performance, educational program evaluation, and related questions. Gagné's position was director of research, and this required, among other things, monitoring the efforts of research teams in three different office locations. This was a busy time, enriched by acquaintance with many highly competent applied scientists in a great variety of fields. This time also saw the appearance of the first edition of his book, *The Conditions of Learning.* Requests for rights to editions in Japan, Germany, and Spain were soon received, and were followed by those from other countries.

Again joining academic ranks, Gagné accepted an appointment in educational psychology at the University of California, Berkeley. Instructional duties here were with graduate students in educational research and other educational specialties. An early task at Berkeley, however, was assuming the post of director of the Far West Laboratory for Educational Research and Development during its initial organizational stage. With the appointment of John Hemphill as laboratory director, the early hectic activity of formative days gave way after six months to programs of more orderly structure. Academic pursuits at Berkeley continued with graduate students in educational research, and with research studies of learning hierarchies and rule learning. In collaboration with colleague W. K. Rohwer, Jr., Gagné prepared for the Annual Review of Psychology the first chapter bearing the title "Instructional Psychology."

Attractive opportunities for the conduct of research on school-related subjects appeared in a Department of Educational Research at Florida State University in 1969, and here Gagné found his most lasting academic home. He collaborated with L. J. Briggs in writing *Principles of Instructional Design* and saw the appearance of the second and third editions of *The Conditions of Learning.* He worked with colleagues to develop a new graduate program in instructional systems design, which has by this time produced many Ph.D. graduates distinguished in this field. His service at Florida State has been interrupted by a fellowship year at the Institute for Advanced Study in the Behavioral Sciences and by a Fulbright fellowship to spend six months in Australia. In the latter location, he enjoyed a visiting professorship in the Faculty of Education at Monash University, where he collaborated in studies of rule learning and memory with Richard T. White.

Recent activities at Florida State have included studies of dissemination of research and development findings to elementary schools, and investigations of remembering by elderly adults who have viewed television documentary programs.

Gagné has been president of the APA Divisions of Military Psychology and Educational Psychology, and president of the American Educational Research Association. He serves as consulting editor to several professional journals, including the Journal of Educational Psychology, Instructional Science, Human Learning, and the Journal of Instructional Development. His honors include the AERA-Phi Delta Kappa award for distinguished educational research (1972), the E. L. Thorndike award in educational psychology (1974), and election to the National Academy of Education (1974).

Gagné and his biologist wife Pat continue to enjoy Tallahassee as a living place. Their son Sam lives in Hartford, Connecticut, and they see their grandson David only on occasional visits. Their daughter Ellen is an educational psychologist interested in the investigation of school-subject learning; she holds a faculty appointment at the University of Georgia, although she is currently on leave and residing in California. Gagné's non-professional pursuits include reading modern fiction and designing and constructing furniture of wood.

Appendix B

Bibliography of Publications by Robert M. Gagné

1939

With N. R. Bartlett. On binocular summation at threshold. *Journal of Experimental Psychology, 25*, 91–99.

1940

With C. H. Graham. The acquisition. extinction, and spontaneous recovery of a conditioned operant response. *Journal of Experimental Psychology, 26*, 251–280.

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1949

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With H. Foster. Transfer to motor skill from practice on a pictured representation. *Journal of Experimental Psychology, 39,* 342–354.

1950

The effect of sequence of presentation of similar items on the learning of paired associates. *Journal of Experimental Psychology, 40,* 61–73.

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