Training for Performance: Principles of Applied Human Learning

Toward General Principles of Training Across Task Domains

This book presents "current psychological research on human learning, memory, and performance as it relates to the practice of training" (p. 1). In the introductory chapter, Morrison describes two general historical trends that occurred in the area of training research in the last few decades. One is the fall of behavioral learning theory and the rise of cognitive theory, that is, a change in interest from the relationships between external stimuli and overt responses to the understanding of cognitive processes underlying task performance. The other trend is the development of system approaches to training, taking into account such aspects as the coordination and integration of media, equipment, methods, and personnel that are required in the process of training people for jobs. Morrison also points out changes in the nature of work that are due to the increase in task automation by computer technology. This increase in automation has had different effects on job requirements, such as an increase in procedural components of the task (e.g., maintenance troubleshooting), more complex problem solving (e.g., text editing with word processing programs), and the necessity to perform several tasks simultaneously (e.g., in aviation).

The chapters underscore these trends in dealing with a variety of topics related to human learning and training. The first three chapters concern rather broad and overlapping issues: acquisition (John Annett), retention (Joel D. Schendel & Joseph D. Hagman), and transfer (Dennis E. Holding) of skill. In contrast to these more basic topics, five of the remaining chapters deal with more practical issues of training, such as task analysis to identify training objectives (John Patrick), instructional strategies for effective training (Gavan Lintern), individual differences (Phillip L. Ackerman & Patrick C. Kyllonen), training media and technology (Greg Kearsley), and the role of organizational and social factors in training (Gary P. Latham & Susan R. Crandall). The book ends with a review of the previous chapters and an outlook for future research (Dennis Holding & John E. Morrison). As such, these ideas would be relevant for students or professionals in such fields as experimental and cognitive psychology, human factors/ergonomics, or physical education.

Basic research on training

In the chapter "Skill Acquisition," Annett gives an overview of various aspects of skill acquisition, which he broadly defines as the process of discovering the behavioral solution to a particular class of problems (p. 13). Even though this definition also encompasses, for example, social skills, Annett restricts his contribution to the acquisition of cognitive-motor skills. He begins by emphasizing the importance of analyzing the nature of the problem to be solved; this analysis should help the instructor or trainer to design effective practice conditions for the learner. Next, he describes various
changes in performance that have been taken as evidence for learning, both quantitative (e.g., "learning" plateaux; power law of practice) and qualitative (e.g., the movement pattern; attention demands; or resistance to stress). Although Annett states that it is "probably unwise to draw firm conclusions about the nature of basic learning processes from the shape of the learning curve" (p. 18), it is striking that he does not really question this approach. Because performance during the practice phase is influenced by a number of temporary factors (motivation, fatigue, etc.) of the independent variables, it is now widely agreed that learning can be assessed only by retention or transfer tests (see Salmoni, Schmidt, & Walter, 1984; Schmidt & Bjork, 1992). We are concerned that Annett does not even mention retention and transfer tests to measure learning, and that his use of the old term "learning curve" implies the idea that these curves in some way reflect learning.

The largest part of this chapter deals with theories of skill acquisition. Using Fitts's (1964) stages of learning as a framework, Annett discusses experimental findings and theoretical approaches with regard to cognitive processes (verbal instruction; demonstration and observational learning), practice (different approaches to explain the negative acceleration of "learning" curves; mental practice; feedback and knowledge of results), and automatization (controlled versus automatic processing; motor programs). Although we cannot go into the details of these sections, several points are particularly striking. One is similar to the point already made above, and it is again obvious in the section on feedback and knowledge of results. Even though Annett (briefly) states that "what really counts" if performance in no-KR (knowledge of results) retention, he still draws inferences from practice performance on learning (e.g., referring to a study by Bilodeau & Bilodeau, 1958a, in which no retention test was used), a view that is clearly outdated. In fact, the whole section on feedback and KR seems somewhat outdated, relying mainly on old studies (e.g., Annett, 1969; Bilodeau & Bilodeau, 1958a, 1958b; Thorndike, 1932). For example, Annett does not mention any of the newer studies dealing with KR relative frequency (e.g., Weinstein & Schmidt, 1990; Wulf & Schmidt, 1989) or bandwidth KR (e.g., Lee & Carnahan, 1990; Sherwood, 1988). Along the same lines, in the section on motor programs, reference to newer conceptualizations in terms of generalized motor programs (Schmidt, 1975, 1985) is missing. The chapter ends with a section on neural bases of motor learning, which complements the behavioral studies reviewed in the other sections.

In their chapter on "Long-term Retention of Motor Skills," Schendel and Hagman correctly point out the "interrelated nature of learning and retention" (p. 53), as well as the practical value of measuring learning in retention and transfer tests. (Because skill learning is measured on retention or transfer tests, one wonders why there are separate chapters on skill acquisition and on long-term retention.) Schendel and Hagman discuss different variables that have been found to enhance motor learning (or retention). These include task variables (response class: continuous, discrete, procedural; organization; display-control compatibility; specificity of displays), procedural
variables (repetition schedule; mental practice; knowledge of results; feedback; test expectation; variability of practice; refresher training), and learner variables (abilities). Not surprisingly, the section on procedural variables (i.e., variables affecting the organization of practice) occupies the biggest part of this chapter. Although Schendel and Hagman's review of the studies is nicely up-to-date in terms of the variables that have been identified to enhance motor learning, it is discouragingly archaic (as is Annett's chapter) in its persistent use of sexist language. A little misleading is the label "variability of practice" for effects of contextual interference (e.g., Lee & Magill, 1983, 1985; Shea & Morgan, 1979). Variability of practice usually refers to variable (vs. constant) practice within the same class of movements (i.e., movements governed by the same generalized motor program), leading to motor schema development (Schmidt, 1975).

Both the Annett and Schendel-Hagman chapters are concerned with practice and knowledge of results, yet the respective sections are not overlapping. This suggests that these, as well as other topics, could have been more thoroughly elaborated. (As already noted above, it might even have been better to have one chapter on skill learning, rather than two, leaving more space for the discussion of relevant points.) Nevertheless, Schendel and Hagman give a useful overview of variables that affect motor performance and learning, and they also point out that these effects can differ with regard to performance during practice and retention (learning). Finally, the authors outline methods to predict retention that are based on the use of task characteristics and learner self-assessment. Especially in this section, but in many others as well, it is obvious that the authors' practical interest is in military settings. And not everybody might agree with their statement that there is "nothing peculiar about military tasks" (p. 55); in fact, with this perspective in mind, some might even be glad that long-term retention will probably never be perfect.

In his chapter "Transfer of Training," Holding addresses different issues related to the transfer of learning. Starting with a description of basic transfer designs (proactive, retroactive transfer), Holding goes on to discuss different methods of measuring transfer and several issues that have traditionally been considered important. These issues include the phenomenon of bilateral transfer, the "similarity" between tasks, the fidelity of simulators, and transfer through learning of rules or principles. Although most of these issues are treated fairly thoroughly, one of the most popular explanations of bilateral transfer, the generalized motor program (GMP) theory (Schmidt, 1975, 1985) is missing. According to this theory, GMPs govern a class of actions, independent of the muscles used to execute the movements. Also, the relative timing inherent in a GMP seems to be important for another aspect of transfer that is dealt with in the section "Special Problems," namely negative transfer. As pointed out by Schmidt and Young (1987), if the same sequencing (order of movement elements) but a different relative timing is required, transfer tends to be negative (e.g., Shapiro, 1978). As negative transfer is usually small, the other "special problems," asymmetrical transfer and part-whole transfer, are probably of more practical importance.
Parts of the last section on "Explanations of Transfer" are rather vague and confusing; this is especially true for "Motor Control Theories." For example, there seem to be some misunderstandings about schema theory (Schmidt, 1975), which Holding refers to as an explanation for transfer within a class of movements. A motor schema is not a "prototype for a range of motor programs" (p. 117), but rather an abstract representation of movement parameters (time, force) used to specify the GMP. As such, contrary to the author’s claim, schema theory is easy to submit to experimental test, and numerous studies have provided support for this notion (see Shapiro & Schmidt, 1982). Also, again contrary to Holding’s view, other theories (e.g., with regard to contextual interference) have not been able to explain transfer within a class of movements (Wulf & Schmidt, 1988).

Applied training settings

In the chapter “Type of Analysis for Training," Patrick examines the role of analysis of jobs or tasks in the development of training, as well as the different types of analysis available. Job, or task, analysis is required to provide information for different stages in the training process. This information can be either task-oriented (used to specify training needs, objectives, equipment, etc.) or psychological (used to select trainees, to design training, and to elaborate the content particularly for cognitively complex tasks). Patrick discusses different dimensions along which task analyses can differ: nomenclature, purpose, descriptive base, structuring procedures, and data collection methods. These dimensions are important in determining the nature of an analysis, that is, they can be used to differentiate between types of analysis, whether they are formal job analysis methods or less formal descriptions of complex cognitive tasks.

The discussion of task-oriented approaches to analysis includes the specification of training objectives, the critical incidence technique (Flanagan, 1954), and the hierarchical task analysis (Annett, Duncan, Stammers, & Gray, 1971). Psychological approaches usually involve some sort of taxonomy, and three types of analysis are reviewed in this chapter: information processing taxonomies (to analyze cognitive processes required in task performance), ability taxonomies (to analyze the task in terms of motor or intellectual abilities required), and taxonomies concerned with types of learning (to specify different training conditions). The last section in this chapter deals with a major problem for training: the analysis of complex cognitive tasks. According to Patrick, there are various methodological difficulties associated with such analyses, and no strong generalizations concerning how to analyze complex tasks have emerged so far. This area seems to provide a promising direction for future research.

Research on “Instructional Strategies” is reviewed in a chapter by Lintern. He defines instructional strategy as a "manipulation or variation on a standard method of practice where the standard condition is an approximation of a self-teaching procedure or one that might be imposed by a conscientious but not particularly innovative instructor" (p. 167). The goal of an instructional strategy is, of course, to enhance learning or transfer, relative to a
"standard" procedure. The definition, however, raises several questions: What characterizes a self-teaching procedure, or one imposed by a noninnovative instructor? Are these not strategies? Lintern complains that there are no useful theories from which hypotheses regarding the effectiveness of instructional strategies could be deduced (which is hard to understand, if one considers newer theoretical developments with regard to contextual interference or the function(s) of knowledge of results for motor learning). However, Lintern does point out that there is some "solid empirical work that can offer a useful guide to the types of instructional strategies that could be useful" (p. 168). Also, contrary to more basic research that, according to Lintern, lacks validity for "real life," the research reviewed in this chapter used tasks of higher "complexity" (whatever that may be) and thus supposedly has more external validity. Lintern focuses on three areas of research: part training, adaptive training, and flight simulation.

Almost all of the studies reviewed by Lintern were conducted under the umbrella of the so-called "Learning Strategies" program. The task used within this program was a video game called "Space Fortress." Lintern reports a number of studies in which the effectiveness of whole-task training is compared with part training ("component drills," i.e., practice of parts of the task before performing the whole task), with component emphasis (e.g., by directing the subject's attention to specific parts), or with strategy emphasis. Even though in some of the studies the amount of practice was confounded with the training method or did not yield significant effects, Lintern concludes from these studies that these methods can enhance learning of the task ("Space Fortress"), compared with whole-task training. Confounds also bring into question some of the results reported in the section on flight simulation.

Overall, Lintern comes to the conclusion that learning benefits can be gained from part training, adaptive training, and different kinds of flight simulation, the main message here being that skill transfer is not necessarily dependent on high fidelity of the simulator or on task similarity. As is often the case with applied research, the question remains about what the results—especially those of the learning strategies program—have to say about the effectiveness of "instructional strategies" in general, other than how to practice a particular video game.

An interesting chapter is the one by Ackerman and Kyllonen on "Trainee Characteristics." The problem of individual differences is often overlooked by researchers interested in training methods that make learning more effective. However, as becomes clear, especially in the last section of this chapter ("Aptitude-Treatment Interaction Theory and Research"), there can be significant interactions between the effectiveness of a training method and the level of some trait in an individual. For example, with regard to contextual interference, interactions with the cognitive style reflection-impulsivity have been found (e.g., Jelsma & van Merriënboer, 1989). Such aspects of training can certainly have important implications in industrial or educational settings. After describing different methods and tactics of
research and applications from the perspective of individual differences, Ackerman and Kyllonen focus on three different issues involving trainee characteristics. The first issue concerns linkages between ability theory and learning theory in the acquisition of perceptual-motor and cognitive skills. The second issue concerns the mapping of learning skills to characteristics of the task or training program. Here the authors view learner characteristics in the context of a “taxonomy of learning skills,” with the major dimensions of the taxonomy being “knowledge type” and “instructional environment.” The importance of this taxonomy is that it suggests hypotheses for “different possible dimensions of learning” (p. 219). The third issue, as mentioned earlier, focuses on an interaction approach to training that includes cognitive, conative (volitional), and affective aptitudes and their interaction with each other and with different training methods. The chapter by Ackerman and Kyllonen points to ways to overcome the traditional tension between individual-differences approaches and training-methodology approaches, so that both can cooperate to make training maximally effective.

Kearsley, in his chapter on “Training Media and Technology,” examines the role and potential of media (i.e., ways of conveying or communicating ideas in an instructional setting) and technology (i.e., devices and methods used to facilitate training). Different types of technology are described and compared, including audiovisual media (print, transparencies, radio/television, slides/tapes, video, videodiscs/compact discs), computer-based systems, and simulators. These sections do not include reviews of empirical studies examining the effectiveness of different media, as one could have expected; rather, they provide an overview of media and technology for training, outlining their characteristics and possibilities. The author’s view is that technology is beneficial for learning and teaching, when used properly. The chapter also addresses the problem of choosing appropriate technologies based on pedagogical factors (such as the type of behavior/skill to be learned, student or situational attributes, and economic or organizational factors), cost-effectiveness analyses, and ergonomic considerations. Implementation issues are also discussed, including the instructor’s role, feasibility studies, management considerations, and sociopolitical factors. Finally, Kearsley outlines future trends in training media and research issues, and summarizes guidelines for the practitioner.

In their chapter, Latham and Crandall focus on “Organizational and Social Factors” that influence the effectiveness of training. The chapter is organized around three themes. In the first section, the organizational culture is examined for its ideology (selection vs. training), demographics (entry-level workers, minorities, women, people over 40 years), corporate strategy (innovation strategy, quality-enhancement strategy, cost-reduction strategy), and the value the organization’s culture places on psychological theory in developing training programs. According to Latham and Crandall, these factors influence not only the content of training programs but also the extent to which an organization offers training to its employees. Organization-wide factors are discussed, namely, factors affecting the trainee “that are primarily
determined by persons or events external to the immediate work group" (p. 266). These factors include pay and promotional policies, and environmental constraints such as the financial health of the organization. Social variables influencing training effectiveness include interactions with trainers, peers, and supervisors. For example, trainers can design training programs that incorporate steps to ensure a high self-efficacy among trainees; also, interactions with peers have been found to enhance learning through discussions of the subject matter and public commitment to performance goals; finally, supervisors can have an important influence on the success or failure of the training program, as, for example, by designing a social environment that facilitates transfer of training. Overall, the chapter gives a well-structured overview of factors that influence the effectiveness of training programs in corporate organizations.

Summary

Overall, the book deals with a variety of topics related to the training process. It is unique in dealing with both fundamental research issues in learning and training and application to real-world training settings. It also provides a rare treatment of a variety of task domains (simple vs. highly complicated; motor vs. extremely abstract and conceptual). Even though it is not quite up-to-date on a number of issues, with some supplementation the book could be used for undergraduate or graduate classes in psychology, human factors, or related fields.

Gabriele Wulf
Max-Planck Institute for Psychological Research
Leopoldstrasse 24
80802 Munich
Germany

Richard A. Schmidt
Department of Psychology
University of California, Los Angeles
Los Angeles, CA 90024-1563

References


---

**Designing Hypermedia for Learning**