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Instructional Technology In the Military

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Prefatory Note

In July 1976, the National Security Industrial Association (NSIA) sponsored the First International Learning Technology Congress in Washington, D.C. As part of the Congress, NSIA also sponsored the Third Triennial Symposium on Cost Effective Learning Through the Application of Technology. One of the six sessions which made up the Symposium was devoted to the topic, "Instructional Technology in the Military." This session was chaired by Dr. Worth Scanland of the Center for Naval Education and Training, Pensacola, Florida.

Mr. David S. Bushnell of HumRRO's Eastern Division was one of three speakers at the session on "Instructional Technology in the Military." His presentation is the lead item in this Professional Paper. It was supported by three other papers written by members of the HumRRO staff—papers which, although not presented at the Symposium, will appear in the Symposium proceedings to be published next year. These three "back-up" papers are also included in this Professional Paper.

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THE IMPACT OF INSTRUCTIONAL TECHNOLOGY ON TRAINING IN THE U.S. ARMY

David S. Bushnell

Almost two years ago, former Secretary of Defense James Schlesinger noted that military training expenditures exceeded $6 billion annually and involved no less than 1/6 of all military personnel at any given time (1). Recognizing the Defense Department's heavy investment in manpower, Schlesinger requested that a Task Force on Training Technology be convened and given the responsibility of evaluating the effectiveness of DOD training. Their objective: to recommend ways of reducing costs and increasing effectiveness of DOD training.

Working over a 12-month interval, from July 1974 to June 1975, the Task Force concluded that too few dollars were being expended on R&D training technology (0.05% of the total DOD research outlay) and that, even with this relatively small investment, considerable progress had been made in promoting cost-effective training (2). Furthermore, they observed that "the Services have pioneered (a) in the use of complex simulators to train personnel to operate and maintain major weapons systems, (b) in self-paced personalized methods of instruction, (c) in performance-oriented training, and (d) in managing the training of very large numbers of individuals" (3). But, they observe, insufficient attention is being given to collective training, that is, the training of crews, groups, teams, and units at a decentralized level. These same sentiments were reiterated four months later when, at the 8th NTEC and Industry Conference in Orlando, Florida, Army Major General Paul Gorman, Deputy Chief of Staff for Training, told attendees that " . . . in this year of 1975, the Captains of the United States Army and the Marine Corps face challenges beyond any that gents of their rank have ever faced in combat in the history of the United States." He then went on to say that both the Army's officers and its enlisted men will be required to make increasingly critical decisions within shorter periods of time (4). The growing complexity of our weapon systems demands sophisticated training programs where simulated engagement exercises are used to polish decision-making skills. The effective operation and maintenance of today's weapon systems requires increasingly able and experienced personnel. How the Army has responded to these demands for improved training programs since World War II is a story well worth the telling.

When Dr. Scanland wrote me several months ago to present a paper on this topic at this first International Learning Technology Congress, I was delighted to do so. In his own persuasive manner, Dr. Scanland asked if I would like to address myself to the advances that my organization, Human Resources Research Organization (HumRRO), has contributed to Army training over the last 25 years through research and development. As if this weren't enough, he then sweetened the pot by inviting me to, in turn, invite three or four of my own colleagues to prepare back-up papers further detailing HumRRO's close working relationship with the Army and contributions in specific areas. To top it off, he offered to publish all four papers as part of the proceedings of this Conference. Thus, much of what follows draws heavily upon the contributions of my colleagues, with the caveat that some of the rasher generalizations which I make later on in my talk are uniquely my own and do not necessarily reflect the views of HumRRO or my associates.

For a more complete and carefully reasoned statement of specific HumRRO experiences touched on briefly here, I refer you to Mr. Lavisky's historical review of Army research on training, Dr. McFann's and Dr. Taylor's discussion of development of performance-oriented training, and Dr. Caro's review of research on the use of simulators in pilot training.

Since 1951, HumRRO scientists have been discovering, developing, and applying human factors and behavioral science principles to the improvement of training and individual performance of Army personnel. Perhaps the best way for me to give you a "feel" for the impact that our research and development program has had on the Army, would be for me to briefly describe Army developments in (1) basic combat training, (2) advanced training, (3) support training, and (4) flight training over the last 35 years. I will conclude my remarks by attempting to identify for you some of the seminal forces which have helped to bring about these needed improvements in training technology. Since the outbreak of World War II, I think you will agree that dramatic progress has been made.

Mr. Lavisky in his companion paper, "Army Research on Training: How it All Began," observes that before World War II, Army training was decentralized, highly personalized, and unstandardized. Because of the small number of enlistees each year, recruits were trained within the regiment which they joined and were likely to remain with that regiment until discharge. Performance standards were set by the regimental commander. Let me underscore two key terms I just used—"decentralized" and "highly personalized." Those are terms that will pop up again in our discussion. I think it is a reasonably safe observation that before the onset of our involvement in World War II, both the Army and Navy, but particularly the Army, were faced with limited dollars for training with the apprenticeship model serving as the principle guide. This status reflected the failure of the military between World War I and II to involve American psychologists and other behavioral scientists in military problems, with the possible exception of the improvement of the personnel selection system (5).

In 1939, the Army was forced to change its approach to training in order to accommodate the masses of soldiers brought into the Service through mobilization. Between 1939 and 1941, for example, three incomplete Infantry Divisions grew to thirty Infantry Divisions backed up by six Armored Divisions. The training model employed was not developed through research, but essentially followed the traditional lecture-oriented, information-centered, time-constrained approach found in most colleges and public schools at that time. The "pointer/podium/poop" approach to Army training was the product of three factors:

1. The need to train a large number of officers, to be used subsequently in the training of enlisted personnel, resulted in a heavy reliance on the traditional lecture method. Such a model was adopted by default. No other learning approach was around to compete with it.
2. The rapid build-up of forces put pressure on military leaders to standardize subject-matter content through the adoption of field manuals as the focal point of training. Since such manuals were organized around subject matter, the training itself was necessarily focused on subject matter. Visual aids were extensively used, putting even greater emphasis on passive listening rather than active involvement in the learning process.
3. The time available for training and the sequence of the subject matter were also standardized. Before then, each company, troop, or battery had its own training schedule determined largely by the Unit Commander's evaluation of needs and time constraints. Eventually, however, greater efficiency and better coordination was realized through standardizing not only the order of subjects to be taught, but the amount of time devoted to each subject as well (6).

It would be inaccurate, however, to characterize basic training as totally lacking in the improvement of performance skills. Target shooting and close-order drill were common events. Extensive use of Army maneuvers with simulated battle sounds and conditions was used to help condition Army units to combat. Few among us will forget the day that we were required to crawl on our bellies with a full pack under a blanket of live machine-gun bullets. We learned to keep our heads down.

Following World War II, the high cost of ammunition together with mounting evidence that basic training as constituted during the war years had a negative effect on recruit attitudes toward the Army, resulted in Army Training Centers adopting a new set of procedures directed at increasing the trainees' identification with his unit and with the Army. It was about this time that the Human Resources Research Office (HumRRO) began to contribute to the improvement of basic training through the application of behavioral and social science concepts.

After the War, the Army's Adjutant General's Office, with its primary responsibility for the improvement of personnel selection and placement, continued to focus much of its attention on testing. In 1947, a small cadre of personnel researchers turned their attention to measuring the results of basic training and of career schooling. By 1950, the Army began to recognize that it was not keeping pace with either the Navy or the Air Force in sponsoring or benefiting from research on the improvement of human performance. A staff study memo dated June 22, 1950 states: "The annual budget allocations for research in human resources in the Department of the Army has been 1% or less of the total research and development budget for the entire Department of the Army." The upshot of this and other staff studies resulted in the Army contracting with the George Washington University for the establishment of HumRRO. Its goals, as shaped by Dr. Harry Harlow, at that time the Army's Chief Psychologist, were threefold:

1. To conduct research in the areas of training methods, motivation and morale, and psychological warfare techniques.
2. To set up a civilian research staff at a central location empowered to grant and monitor contracts to educational, business, and industrial organizations as well as provide technical supervision of research conducted at military installations.
3. To establish in-service research units at appropriate military installations who were, in turn, directed to work with HumRRO's staff on a collaborative basis.

During the first four years of HumRRO effort, we learned that the training context provided the most productive area of focus in attacking morale, motivation, leadership, and training problems. Research goals were specified in an Annual Work Program initially agreed upon by the Army and HumRRO. Organizationally, three research divisions, the Director's office, and supporting services were initially located on the University's campus and later in Alexandria, Virginia. By 1958, five field divisions had been formed and co-located with military research units at major Army installations throughout the country. Almost from the beginning, the HumRRO research staff was augmented by Army personnel located at the field division sites or detailed for work at corporate headquarters in Alexandria, Virginia.

Basic Combat Training (BCT)

Among the first series of studies conducted by HumRRO was an evaluation of the impact of basic training on Army recruits. (See, for example, references 7 and 8.) One of the more significant products of that research, aimed at increasing the recruit's identification with his unit and with the Army, was the establishment of a five-week training program for Army Drill Sergeants. A four-man HumRRO team worked for several months with Army training personnel to develop a training program which would help the Drill Sergeant learn more about motivating recruits, developing trainee skills, and building *esprit de corps.* Please note that HumRRO personnel did not design such a training program in isolation, but spent several months in close collaboration with Army training personnel. Subsequently, Army Drill Sergeant schools were established at a number of Army installations.

Another major change in recruit training came about in 1957 when the Army adopted a rifleman training procedure (for use during both day and night) which put stress upon first studying and then simulating the combat rifleman's job. Before that, marksmanship skills were developed by having a recruit fire at bull's-eye targets at known distances just as he might in competitive marksmanship matches. Under the new procedure (9), the trainee was taught to spot and estimate the distance of a pop-up silhouette target (dubbed "Punchy Pete") which dropped when it was hit. Night-firing marksmanship programs, based on the concept of aligning the rifle without using its sights, resulted in a 60% to 210% increase in accuracy over previous training methods. Here again, HumRRO researchers worked on-site at all of the major Army training locations, including Forts Knox, Benning, Rucker, Bliss, Ord, and later on, at Fort Hood. Studies were also conducted in the field at a variety of Army operational sites, including Europe, Korea, and Viet Nam. Close collaboration with military personnel helped to ensure adoption and implementation of recommendations derived from the research.

Most of the BCT studies (and subsequent efforts) had as their origin a specific operational problem. Every effort was then made to generalize the finding to other comparable situations. Thus, the value and utility of HumRRO work tended to follow an experimental curve of usefulness over time. The degree of success achieved in solving problems was thought to be a function of timeliness, changes in Army priorities (compatibility with established practices), skill in communicating results to key decision makers, and characteristics of the innovation itself, e.g., its obvious advantage over older practices in terms of efficiency (10). Our close proximity to and collaboration with Army personnel helped gain acceptance for our findings and recommendations as well as establish the credibility of the HumRRO effort.

One dramatic illustration of this occurred in 1966 when the Army adopted a service-wide regulation (CONARC Reg 350-100-1) which was used to guide the development of all training programs between 1966 and 1971. This "systems engineering" approach required that precise behavioral objectives for training be developed through a careful job analysis and that the specific subject matter selected for the training program be included on the basis of its relevance to the tasks to be performed. Criterion-referenced tests designed to assess individual mastery of various performance objectives were also introduced (11). Thus, up to 1966, HumRRO's integrated research and development program not only focused on improving basic training, but it was equally concerned with job analysis and evaluation procedures, the improvement of instructional methods, and developing a better understanding of the learning styles and characteristics of trainees. Testing and evaluation procedures developed at the same time helped to ensure that the basic recruit, upon completion of basic training, could perform the necessary skills and could demonstrate that he had the knowledge required of a foot soldier.

Advanced Training

Even with these advances, much remained to be done in the areas of Advanced Individual Training (AIT) and Support Training (ST). The pattern adopted during World War II of lecture-centered, standardized courses oriented to group instruction persisted in the classroom. Even in the periodic renewal of manual skills, such as rifle firing, little attention was given to more optimal schedules of reinforcement designed to maximize skill retention. Fortunately, outside the classroom, a number of exceptions occurred.

After completion of BCT, a recruit was often assigned to rifle squad training where techniques of fire and patrolling skills were taught, based on HumRRO analyses of what a soldier must know and do in actual combat (12). In addition, eight fundamental night-operation skills were taught. These too, were derived from field observations by HumRRO scientists (13).

Had the BCT graduate been assigned to other AIT programs, such as Armor or Air Defense, he would have been presented with on-the-job aids in a functional context. Here the material to be learned was broken down into a step-by-step procedure with specific instructional techniques for use by recently graduated peer instructors. Air Defense missile gunners were taught to recognize enemy aircraft through a procedure developed by HumRRO personnel (14). The Combat Development Command recommended that this prototype program be adopted for training all forward-area air defense gunners.

Support Training

Recruits graduating from basic training were also assigned to non-combat roles in what were called "support" positions. Radio operators, medical corpsmen, supplymen, and cooks all benefited from research on how to formulate training objectives, select course content, and alternative instructional methods and procedures (aimed at increasing training efficiency and reducing attrition). This "systems engineering approach" resulted in a 10% to 15% reduction in training time while maintaining or enhancing the performance of graduates.

In 1966, a major new recruitment policy was adopted by all the Services. They agreed to dramatically increase the number of lower mental ability recruits accepted into military service. HumRRO was asked to undertake a series of studies to determine what effect this policy would have on the training and utilization of personnel in the Army. It was feared that the Army's continued reliance upon passive classroom lecture and paper-and-pencil (normative) tests would prove to be ineffective with lower mental ability personnel.

Shortly thereafter, college deferrals were abandoned. The resulting heterogeneity of recruits demanded an even more flexible form of instruction. Between 1968 and 1972 the HumRRO research and development effort focused on devising instructional approaches which would accommodate widely varing aptitude levels. As an example of how this series of new studies was organized, let me describe in somewhat more detail a recent systems engineering effort of eight Combat Arms Military Occupational Speciality Codes (MOSs).

The Combat Arms Training Board (CATB) of the Army had discovered that those responsible for training operational units needed assistance in increasing the proficiency level of their non-commissioned officers. Trainers at the unit level had neither the methodology nor the material to conduct adequate training. The combat arms soldiers were also complaining that they had little chance to develop their skills beyond the rudimentary level. The first step taken in solving this problem was to attempt a simultaneous systems engineering of eight Combat Arms MOSs. We were able to take advantage of the commonalities among tasks that existed between various duty positions. In this way the training could be made more efficient if common tasks were identified and training materials developed once rather than several times by different combat arms trainers.

In this clustering study, 93 different duty positions were identified and task inventories developed on each. A classification system was used to permit comparison of the material from each position. The tasks were identified by category, such as first aid, land navigation, and tactics. Within each category tasks were broken out into three levels: (1) fundamental—those tasks expected to be common to all soldiers in the Army; (2) branch—those tasks expected to be common to duty positions in a given branch; and (3) MOS—those tasks associated with specific duty positions. Task descriptions were validated by three different groups: job incumbents, senior NCOs, and officers. Job task data (e.g., job conditions, knowledge and skill requirements) were developed for all tasks that were performed by 60% or more of the job incumbents. That information was then used to develop training objectives, training materials, reference manuals, evaluation criteria, and MOS test questions. The information thus developed proved to be an important input for curriculum planners, training administrators, and training developers at each of the Combat Arms Schools. This required an immense amount of coordination between the Army, three of HumRRO's research divisions, and CATB (15).

Emerging out of the mass of recent research on the training process are six principles which deserve to be recapitulated here. They are:

1. Performance-based Instruction. Students learn the skills necessary for job performance. The emphasis is on active skill practice—"doing" rather than "passive absorption of information."
2. Task Mastery. Every student is required to reach a particular standard of performance in each skill. Assessment is on a "go/no-go" basis. The student who does not reach the criterion level of performance receives additional practice until he does reach it.
3. Functional Context. The student learns in a job-relevant situation. Theoretical or technical material is presented only when it is needed in learning to perform a skill.
4. Individualization. For various reasons people learn at different rates. To the extent possible, the trainee is permitted to learn a skill at his own rate.
5. Feedback. If the instructor and curriculum developer know a good deal about the student to be taught, instructional methods can be modified to be more effective. If the student knows about his own skill acquisition, he is motivated to correct errors of inadequate performance.
6. Quality Control. To ascertain that the training system is functioning properly, student performance must be systematically assessed at various times during and at the end of training.

Flight Training

Before I bring my remarks to a close, I would like to comment on one other area of HumRRO research: the training of helicopter pilots. As everyone knows, aviation training is costly. The high cost of fuel combined with the increasing value and complexity of Army aircraft led HumRRO to propose to the Army that it attempt to improve its evaluation of pilot performance and to employ less costly flight trainers in teaching maneuvers. As a result of this research, the Army helicopter trainee gets his first taste of rotary-wing flight in a helicopter training device. Men trained on this device experienced significantly less attrition during the subsequent flight training—only 10% attrition compared with 30% attrition under previous procedures—and they made better grades and soloed earlier (16).

Paul Caro's excellent review of research on the role of simulators in pilot training explores those factors which influence the transfer of simulated training to operational aircraft. Six factors were shown as having significant impact on simulator training effectiveness. Simulator design, visual fidelity, motion fidelity, handling characteristics, etc. were judged from the vantage point of their influence upon training effectiveness. Other variables (such as the sequence of instruction employed, individual vs. group pacing, training to specified criterion levels, and length of exposure to training on a simulator) need investigation if the proper combination of hardware, training program, and personnel is to be ascertained. Caro concluded that while simulator training artisans can sometimes produce spectacular results, there are too few such individuals to develop and continuously update all of the simulator training programs required by military and civilian pilot training establishments and operational units. He concludes his paper with a plea for more case study reports of simulator training applications so that conceptual models might be developed for future applications and research. Gathering data on existing simulators and training programs would, he argues, provide a broad data base for judging the effectiveness of simulator training. Through this approach, extensive savings might be realized through designing simulators to meet training specifications. One such device, whose commercial procurement costs would have been about $75,000, was fabricated by the Army to HumRRO specifications at a cost of less than $5,000.

Summary and Conclusions

What began as a decentralized, somewhat individualized and unstandardized approach to pre-World War II training has come full circle. While it would be misleading to characterize today's training principles as identical with those followed during the period between 1918-1939, they are parallel in the sense that greater emphasis is now being placed on decentralized decision making, expanded use of self-paced and individualized instruction, and greater flexibility in training approach. What has emerged from a sustained period of research and development is a more pragmatic, sophisticated approach to the orderly development of Army training. Starting with a careful and detailed analysis of a particular job function and progressing step by step through the specification of needed knowledges and skills to the determination of training objectives and the organization and evaluation of the training program, HumRRO has helped to create a generalizable procedure that has proved to be of considerable value as new training tasks are undertaken.

In closing, it should be recognized that the procedures just outlined are only as good as the learning theory upon which they are based. The interaction between theory and empirical observation, coupled with the involvement of military personnel in priority setting and the implementation of results, has resulted in an unusually productive and beneficial relationship.

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ARMY RESEARCH ON TRAINING: HOW IT ALL BEGAN

Saul Lavisky

The Seeds: Selection and Classification Procedures

At the outset of World War II, the U.S. Army already had a 166-year history of training its soldiers, and had never lost a war. By contrast, educational research and psychological research on education had not, by 1941, achieved much success in improving the nation's educational practice. How did it come to pass that the Army turned to psychology for help in the immensely practical task of training its soldiers?

It would be as wrong to suggest that Army interest in, and use of, scientific training research resulted from some grand, preconceived scheme as it would be to suggest that the Army arrived at its current advanced stage of training technology by a series of fortuitous accidents.

The seeds of psychological assistance in Army operations were actually sown in World War I, when a special committee of the American Psychological Association began exploring methods and procedures for testing and classifying new recruits. (1) The psychological profession was a small and relatively new one at that time; the American Psychological Association had only 336 members in 1917. But this group quickly established its utility to the Army by adapting some "exploratory IQ tests" into the *Army Alpha* group test for classifying literates and the *Army Beta* for classifying illiterates. It is not an overstatement to describe these tests as "landmarks" in the mental measurements movement—landmarks paralleling the individual intelligence test devised by Binet early in the twentieth century.

Much of the other work that psychologists performed for the Army during World War I is now noted only in specialized histories Yet a list of those psychologists includes the "giants" of the profession: R.M. Yerkes (who directed the program); R.S. Woodworth (who developed tests to predict courage under stress); Edward L. Thorndike (who devised tests to identify potentially successful aviators); and J.R. Angell, Louis M. Terman, and John B. Watson (who initiated development of classification procedures.) Also included were W.S. Hunter, L.L. Thurstone, G.M. Whipple, Edwin G. Boring, Horace B. English, and Arthur S. Otis. (2)

When World War I ended, these men returned to their civilian pursuits, as did most of the 1,726,966 soldiers who had been "psychologically examined," in groups and individually, on tests they had developed.

In the years between World War I and World War II, American psychology advanced on a number of non-military fronts, including the psychological measurement of human aptitudes and abilities and educational psychology.

When General George C. Marshall became Army Chief of Staff in 1939, he established a Personnel Testing Section in his Adjutant General's Office and set that group to work developing the first edition of the Army General Classification Test (AGCT). The test was first used in 1940. Fortunately, it was available when Congress passed the Selective Service Act and the "draft" began to present new men by the tens of thousands for Army service. As the Army moved to a wartime footing, the Personnel Testing Section was enlarged into a Personnel Research Section which developed a whole variety of selection and other types of "predictive" tests in support of the Army personnel system. These included achievement and aptitude tests, selection programs, and tests of all kinds of abilities. Even attitudinal research was conducted by the Army's psychologists and sociologists. (3)

We need to remember that, at this point in American military history, there was no separate air arm. The Army had its earthbound soldiers in the Army Ground Forces and Army Service Forces, and its airmen in the Army Air Forces. All were under the command of a single Chief of Staff, General George C. Marshall.

General Marshall is known to have been extremely concerned not to repeat the training mistakes of World War I, which had seen so many ill-prepared soldiers shipped from the U.S. to the trenches in France. But, from the time he became Chief of Staff in 1939 until just before the attack on Pearl Harbor, he had to spend most of his time and energy enlarging the Army, housing, and equipping it. Even today, 35 years after the fact, his role in the passage of the Selective Service Act, in its extension (less than a year later), and in the call-up and retention of the National Guard, makes exciting reading. (4)

Army Training

Before World War II, Army training had been decentralized, highly personalized, and extremely unstandardized. This kind of training "system" was possible because of the relatively small number of new enlistees each year. The recruit learned basic soldiering skills as well as the rudiments of his job within the regiment in which he would serve—a military version of apprenticeship training.

With World War II on the horizon, it was necessary in 1939 for the Army to change its approach to training in order to accommodate the masses of soldiers it had to train—hastily—for both the mobilization and casualty-replacement stages of the war. Training was centralized in Replacement Training Centers (one or more for each branch), depersonalized (because of the large numbers of recruits involved and the constant turnover in trainers), and relatively standardized (on paper, if not in fact).

The Ground Army was nearly overwhelmed by the job. Between 1939 and 1941, for example, it grew from three incomplete Infantry Divisions to 30 Infantry Divisions, complete in number and improving in quality, backed up by six Armored Divisions. The fledgling Army Air Corps was producing 30,000 pilots per year, and was planning for 37,000 new pilots in 1942. By the time the build-up was complete, the Army had 100 divisions. (5)

Although the Army Ground Forces—the major command responsible for training ground combat troops—did not sponsor or support any formal research to improve its instructional programs, it did attempt to use the best available "technology." Some of these attempts were successful. Some were considerably less so.

The Armored School at Fort Knox, Kentucky, representing one of the Army's newest branches, prepared an elaborate program for its incoming instructors. The Commandant turned first for assistance to civilian industrial educators. The program they designed had new instructors meeting an hour a day for three months. But the subject-matter was too arcane for the audience—psychology, statistics, job analysis, learning theory—and not a reference to Field Manual 21-5 on "Methods of Instruction," with which all the instructors were reasonably well acquainted.

In less than a year, the Commandant fired his civilian "experts" and brought in a Reserve officer who had been a teacher in civilian life. This wise gentleman discarded all reference to educational theory and made practice teaching the heart of his course. He required each new instructor to plan and present one short lesson and one long lesson, of the kind they would actually be presenting on the job. The new program ran four hours a day for two weeks and, when the training phase ended, the program included irregularly-scheduled monitoring of the new instructors in their classrooms. Other Army schools followed this example with such success that the Armored School became, and remains to this day, the proponent Army agency for "methods of instruction" matters.

Following the War, the American Council on Education established a Commission on Implications of Armed Services Educational Programs. Some 258 educators who had served in the Armed Forces were asked the most important features of armed services training. While there was considerable agreement on the ten top features, there was almost unanimous agreement (92%) that the single most outstanding feature was use of visual aids in military training. (6) In fact, it was estimated that the quantity of audio-visual aids created and used by the Army and Navy between 1940 and 1945 was six times the quantity of similar material created for use in all civilian education in all earlier years. (7)

Training Research

For the element of training *research*, we must turn our attention to the Army Air Forces and, specifically, to the Army Air Forces Aviation Psychology Program. Even an amateur historian knows better than to assert a precise date for any long-time, continuing trend, but one possible date for the beginning of scientific training research in the Army would be July 15, 1941. On that date, Dr. John C. Flanagan, Associate Director of the Cooperative Test Service, was commissioned a major in the U.S. Army and called to active duty to establish a psychological agency in the U.S. Army Air Corps (later to become the U.S. Army Air Forces). He reported for duty in Washington, D.C., the following day to set up plans for developing and validating a battery of printed and apparatus tests for use in selecting pilots. (8)

Major Flanagan moved promptly. Within a month he had sketched the outlines of a program and had obtained commitments of cooperation from the Air Corps Training Division. He established a Psychological Research Unit at Maxwell Field, Alabama, to develop tests of personality and temperament. This unit was headed by Laurance F. Shaffer. He established a second research unit at Kelly Field, Texas, under Robert T. Rock, to develop psychomotor tests. He also established a third research unit at Santa Ana, California, under J.P. Guilford, to develop printed tests of intellectual functions.

Over the next 4-1/2 years, the Air Forces Aviation Psychology Program utilized the services of some 165 officers, 1,255 enlisted men, and 25 enlisted women (WACs). It was, at the time, the largest assemblage of psychologists ever to work on a common problem—improving the personnel system of the Army Air Forces. It is an obvious injustice to the many to single out a few names of program participants. I do so here only to give readers a "feel" for the caliber of personnel involved in the program. Among them were: Judson Brown; Urie Bronfenbrenner; Launor F. Carter; Meredith P. Crawford; John T. Dailey; Philip H. DuBois; Stanford C. Ericksen; I.E. Farber; Glen Finch; N.L. Gage; Robert M. Gagne; Robert Glaser; Frank A. Geldard; Edwin E. Ghiselli; Walter F. Grether; John K. Hemphill; Roger W. Heyns; Nicholas R. Hobbs; Paul Horst; Lloyd G. Humphries; Edward H. Kemp; Joseph T. Klapper; William A. McClelland; Arthur W. Melton; Neal E. Miller; Gabriel D. Ofeish; Henry W. Riecken, Jr.; Roger W. Russell; Benjamin Shimberg; Lawrence M. Stolurow; Robert L. Thorndike; J.E. Uhlaner; T.R. Vallance; and S. Raines Wallace.

As Dr. Robert L. Thorndike pointed out after the War, the Aviation Psychology Program actually went through two phases: first, the development of selection and classification tests and procedures and, later, attention to *other* psychological aspects of military effectiveness. (9) One major activity in this second phase was research on training—primarily training for pilots, navigators, and bombardiers, but also training for other aircrew members. Space does not permit any discussion of the substance of this research but, thanks to the wisdom and persistence of Dr. Flanagan, the written record survives.

During the war, most of the work of this extensive program was known only within the military. "National security" kept program participants from traditional publication in scientific journals, and the limited copies of their research reports began disappearing as the war drew to a close. With the cooperation of a number of his wartime colleagues, Dr. Flanagan conceived and shepherded through the U.S. Government Printing Office a 19-volume series of *Army Air Forces Aviation Psychology Program Research Reports*, published in 1947. When I stumbled into the military training research field in 1963, this series of reports was already long out of print. A few years later, in my own major contribution to the field, I was able to persuade the Defense Documentation Center (which does not normally accept materials published by the USGPO) to make an exception in the case of these research reports. The complete 19-volume set is now permanently available in hard-copy and/or microfiche from both DDC and the National Technical Information Service (NTIS). The record is preserved!

The Post-War Period

When World War II ended most of the psychologists in the Aviation Psychology Program traded in their uniforms for mufti and returned to their university classrooms and laboratories. Those who wanted to continue in aviation psychology were able to do so in the United States Air Force, which came into its own in 1947 as a Service separate and apart from the Army. The leaders of this new Service quickly demonstrated their conviction that psychology had much to offer the Air Force by creating, in rapid succession, the Human Resources Research Center within the Air Training Command; the Human Resources Research Laboratories (later called the Human Factors Operations Research Laboratories) within Headquarters Command, USAF; and the Human Resources Research Institute in the Air University Command. In 1954, these laboratories were all transferred to the Air Research and Development Command, which merged them into its own Air Force Personnel & Training Research Center (AFPTRC). But that is a separate story and, for us following the path of *Army* training research, it is the wrong fork in the road—worthy of following in its own right, but unable to take us where we want to go today.

The Personnel Research Section in the Army Adjutant General's Office had continued working throughout the World War II demobilization period, primarily in its traditional areas of selection, classification, and assignment. In 1947, some members of the Section turned their attention to problems of military training—specifically, to problems of measuring the *results* of basic training and of career schooling. However, this work represented only a small proportion of the Section's efforts, which continued to focus on psychological testing.

As 1950 rolled around, the Army was still not actively engaged in, or supporting much research on training. The situation was described by an unidentified author in an Army staff study, "Human Resources Research Program within the Department of the Army," dated June 22, 1950:

> Applicable regulations are at variance in placement of responsibility for supervision of research and development activities within the Department of the Army. . . . The responsibility for implementation of research and development in the field of human resources is widely scattered among (a) the various Technical Services; (b) the Personnel Research and Procedures Branch, Office of the Adjutant General; (c) Office, Assistant Chief of Staff, G-2; (d) Research and Development Division, Office, Assistant Chief of Staff, G-4; and (e) other agencies which may be assigned the responsibility. . . . The Department of the Army has not at any time provided personnel in sufficient quantity and quality to give General Staff supervision to research in human resources in any degree comparable to that provided in either the Navy or the Air Force. . . . The annual budget allocations for research in human resources

> in the Department of the Army has been 1% or less of the total research and development budget for the entire Department of the Army. . . . there has been at no time sufficient staff to give attention to the needs of the Department or to do the necessary overall and long-range planning prerequisite to the development of an adequate program. . . . Human resources research is much more likely to be dealing with intangibles, and the end products are more difficult to appraise. For these reasons, it is more subject to curtailment in times of budgetary or appropriation shortages.

Later that year, another staff study, "An Army Program in Human Resources Research" (November 28, 1950) concluded that "Human resources research can provide valuable assistance to the Army by producing and evaluating practical methods and techniques which will increase the effectiveness of human beings in military operations." The study recommended establishment of a Training Research Unit at some Army post where there was both a division and other tactical units being trained, and if this unit proved successful, others would be established elsewhere in the Army.

On January 12, 1951, another staff study, entitled "Responsibility for General Staff Supervision of Human Resources Research," recommended that conflicting Army Regulations be written to place this responsibility solely with the Research and Development Division, Office of Assistant Chief of Staff, G-4. (The responsibility actually was vested later that year with the Office of Assistant Chief of Staff, G-1.)

How far "up the channel" any of these studies actually floated is unknown to me, and is important, perhaps, only insofar as they were precursors to a staff study that did get action, and that did put the Army solidly into training research. That crucial study, "An Integrated Program in Human Resources Research," was written primarily by Dr. Harry Harlow, who then worked in the G-4 Research and Development Division as the U.S. Army Chief Psychologist. It was submitted to Army Chief of Staff J. Lawton Collins on June 7, 1951. Among its recommendations were the following:

> 9. That a major contract be awarded to a recognized educational institution to provide for the formation of a Human Resources Research Office, which would have primary responsibility for conducting research in the areas of training methods, motivation and morale, and psychological warfare techniques.
>
> 10. That the Human Resources Research Office carry out its responsibility by:
>
> a. Conducting researches at an established central office.
>
> b. Granting and monitoring contracts to appropriate educational, business, and industrial organizations.
>
> c. Providing the civilian staff for in-service research units and furnishing technical supervision of research conducted at military installations.
>
> 11. That appropriate research units be established at selected military installations to give primary research emphasis to the following areas:
>
> a. Training methods.
> b. Motivation and morale.
> c. Psychological warfare.

Two weeks later, General Collins called Dr. Harlow into his office for a briefing on the proposal and for a question-and-answer session. When he had satisfied himself on the soundness of the plan, General Collins transmitted the study with its proposals and his endorsement to the Secretary of the Army.

On July 27, 1951, the Army entered into a contract with The George Washington University for the establishment of a Human Resources Research Office (HumRRO) to carry this concept into action. Dr. Meredith P. Crawford, who had headed research units in the Army Air Forces Aviation Psychology Program and who was then Dean of the College of Arts and Sciences at Vanderbilt University was invited to come to Washington to head this new Office and program.

From this beginning, Dr. Crawford and his colleagues in HumRRO have provided the Army—over the past quarter-century—with a training research program that has brought credit to the Army and to themselves. HumRRO scientists, primarily psychologists, have been effective in helping to move the Army to its present stage of extremely effective, and still improving, training and education programs.

The work that begain in the Aviation Psychology Program in World War II and continued in the Army under HumRRO has demonstrated that consistent improvement in educational methods and practice can be based on a systematic application of the methods of psychclogical science. By 1951, with the establishment of the Human Resources Research Office, the Army was on its way toward the development of a practical technology of instruction.

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ATC-PERFORM:

A CASE STUDY IN INDIVIDUAL MILITARY TRAINING RESEARCH AND DEVELOPMENT

H.H. McFann and J.E. Taylor

Background and History

This paper describes the impact on the operational Army of an applied research and development effort undertaken by HumRRO under the code name ATC-PERFORM. A bit of history is required to place this activity in perspective.

Since 1952, HumRRO has been involved in working with the Army on projects related to training center operations. In the early 1960s, the Army and HumRRO mutually agreed that one of the HumRRO Divisions should be involved exclusively in research and development with Army Training Centers. Prior to this, research and development efforts involving Army Training Center activities had consisted of discrete activities, not necessarily related, which focused on specific aspects of Training Center operations. They resulted in package programs that could be inserted into the existing operational framework. Although these projects had resulted in meaningful change, their potential impact was somewhat limited. It was felt that devoting a large effort, over an extended time period, to the total training center system would magnify the potential impact and contribution of training research and development.

From the start, the Army and HumRRO were in agreement on both the area of concentration and the cooperative nature of the venture. The Army would support the research, providing ready access to the personnel and activities of a Training Center. HumRRO would devote an agreed-upon level of effort to this joint venture, providing technical advisory service to the Army as well as maintaining an integrated research and development program focused on Army Training Center problems. Thus, the intent from the start was to move through iterations of research, development, testing, evaluation and utilization cycles in order to make change in Army training operations from a sound empirical data base.

From 1961 to 1966, HumRRO undertook an integrated program of research and development aimed at studying the various components of overall Army Training Center operations. Topics included activity analysis, management and leadership practices, instructional content and methods employed, evaluation procedures, and characteristics of trainee input and cadre. Numerous products evolved which guided future research and development efforts and resulted in changes in existing practices; e.g., the Drill Sergeant Program, the Leader Preparation Program, moving from a single evaluative instrument for assessing BCT proficiency to multiple alternate forms, and individual course revisions.

In about mid-1966, a major policy decision was made which affected the direction of the research and development activities as well as the operation of the Training Centers. Project "One Hundred Thousand" was initiated which dramatically increased the input of lower mental aptitude (AFQT Category IV) recruits into the Army's training population. HumRRO undertook a series of studies to determine what effect this policy change would have on training and utilization of personnel. Examination of the then current instructional system for Basic Combat Training and Advanced Individual Training as conducted in Training Centers indicated that the system was hard pressed to carry this new input.

Generally speaking, the system at that time could be characterized as a fixed-paced group system, relying primarily on a passive classroom-lecture instructional paradigm which utilized normative evaluation procedures with a heavy reliance on paper-and-pencil testing. This system had worked reasonably well for higher aptitude groups, and it could cope with the small number of lower mental ability personnel who had historically been in the system. But the magnitude of this new trainee input over-extended the system.

A further training problem occurred when the policy decision was made to do away with college deferments. The result was a training load characterized by a very wide spread of individual ability, ranging from functional illiterates to college graduates. The fixed-paced, group-lecture mode employed in the Army Training Centers could not handle this diversity of personnel. The more able people were lost to boredom and the less able were often lost to attrition.

From about 1968 to 1972, this HumRRO research and development effort concentrated on conceptualizing, developing, and testing instructional strategies for training personnel across this wide ability spectrum. Individual differences, as related to training and performance, became paramount areas of interest. Research and development activities included laboratory studies concerned with content, instructional approach, and aptitude level; development and test (in an operation context) of instructional systems geared to handle the heterogeneous training population; provision of consulting services to Army personnel in their revision of the heavy density AIT combat and combat support courses; and determination of how various aptitude personnel performed on the job.

In the spring of 1970, the Department of the Army undertook a broad and long-range plan for conversion to the All-Volunteer Army. HumRRO was requested to help formulate the master plan for guiding training innovations, and in conjunction with Fort Ord, to develop and test the Experimental Volunteer Army Training Program (EVATP) which was to serve as a model for all Army Training Centers. This massive developmental undertaking involved all aspects of the Training Center: organization, management, instructional systems, instructor training, and evaluation. All of the previous research and development activities served as a springboard for this "cold water" bath of reality testing. It was here that the previously researched concepts of performance-oriented instruction and criterion-referenced testing were subjected to large-scale experimental field evaluation. Of equal importance, it was during this implementation phase that the problems of resistance to institutional change became crystal clear. However, the solutions to such problems remained somewhat murky.

In April 1971, the U.S. Continental Army Command (now the U.S. Army Training and Doctrine Command--TRADOC) directed that all training programs conducted in Army Training Centers be reviewed and revised in accordance with systems engineering of training and the principles of the EVATP, performance-oriented instruction and testing. HumRRO technical assistance was to be used during revision or redesign of instruction. From 1971 through June 1972, HumRRO personnel, in addition to working with Fort Ord personnel on further refinement of the performance-oriented testing and training program, became actively involved in the accomplishment of such system change. Activities involved consultation in the development of implementation guidance documents and a large number of orientation visits to training centers and Army schools to promulgate the concepts and techniques of performance-oriented training and testing. Direct assistance was provided to the training staffs of AIT combat support courses (e.g., Cook, Wheel Vehicle Mechanic, and Radio Operator) in preparing performance tests and modifying training techniques for these courses. Guidance was provided in modifying NCO Academy and Drill Sergeant programs to insure not only that these principles were incorporated into the content of their training programs but also that their course of instruction was based upon them.

By spring 1972, the training concepts had been implemented in all CONUS Army Training Centers where Basic Combat Training and Advanced Individual Training in the combat military occupational specialities were being conducted.

ATC-PERFORM

Such is the history and background which spawned ATC-PERFORM, an effort that was to extend over the years 1972-1975. Its specific objective was to provide technical research and development assistance to Army agencies involved in the review, evaluation, and refinement of performance-based training techniques in Army Training Centers. It extended the Army's effort to accomplish major training innovations that had been initiated with the EVATP in 1971-72 during conversion to an all-volunteer status. Research and development assistance was provided in such diverse activities as task analysis, performance test development, instructional systems development, conduct of evaluations, design of experiments on the effects of instructional innovations, collection and analysis of questionnaires and interview data, generating or revision of training literature, and orientation of training managers and instructors.

Examination of these myriad activities gives some idea as to the scope and nature of this effort. From an instructional technology perspective, emphasis was placed on further codification of the principles developed and tested under the rubric of performance-based training and testing, and on extending this instructional technology. Equally important was the accomplishment of institutional change. Actions were taken to involve Army personnel in the conversion of specific courses and programs of instruction, and to make certain that policies and procedures were established insuring that the gains achieved in instructional effectiveness and efficiency through application of the principles would become institutionalized.

The principles have been implemented in various configurations, in the following Army Training Center Programs: (a) Basic Training (Basic Combat Training for Men, Basic Training for Women); (b) Advanced Individual Combat Training (Infantry, Armor, Field Artillery, and Air Defense Artillery); (c) Advanced Individual Combat Support Training (Signal, Transportation, Ordnance, Clerical, Quartermaster, Military Police, and Engineer). (d) NCO leadership and instructor training courses; and (e) training for Reserve Components. The institutionalizing of these concepts and techniques is reflected in a variety of Army training documents including Army Subject Schedules, Programs of Instruction, and Army Training Programs; in a number of pamphlets in the TRADOC 600 Series; in instruction and assessment materials for a wide variety of specific courses of instruction, and in Army staff policy decisions.

The concepts of One Station Unit Training (OSUT) and One Station Training (OST), which involve the combining of Basic and Advanced Individual Training, grew out of the EVATP and this program of research. Recent legislation based partly on ATC-PERFORM data, permits training time to be reduced to 12 weeks. This modifies a Public Law that had been enacted during the Korean War specifying that training be at least 16 weeks. A number of courses previously mandated to be 16 weeks in length are being selectively reduced by as much as four weeks (e.g., armor crewman, light weapons, infantrymen, Military Police, telephone lineman).

As part of ATC-PERFORM activities, experimental systems of self-paced instruction were tested out in supply (cognitive) and heavy equipment (motor skill) courses which had been previously converted to performance-based training and testing. The results indicated that self-pacing in combination with performance training is feasible, practical, highly effective, and provides the potential for accelerating individuals through the training base. (Savings of some 25% in training time were achieved with no decline in skill proficiency.) Drawing upon this research, TRADOC is directing that Army MOS-producing courses be based upon performance training principles and that they include self-pacing. Thus, the operational impact of this research will likely continue for at least the next two or three years.

Research and development has, throughout, attempted to remain responsive to major policy decisions such as Project One Hundred Thousand, the All-Volunteer Army, and the Army's draw-down in funds and resources. The goal has been to find ways to insure that Army training prepared the spectrum of trainees for their Army assignments in the most efficient manner possible, efficiency being defined as the ratio of skill proficiency to training costs. Accomplishment of this goal has requried continuous study of the complete job training system (course development, course structure, course management, and training methods).

In summary, ATC-PERFORM has been a major catalyst for accomplishing institutional change in the instructional system used in Army Training Centers. The change has affected training managers, instructors, and trainees. Change in instructional methods has been directed away from the platform and subject-oriented systems to a performance-oriented system. Training objectives that facilitate an individual's learning entry level job skills are emphasized. Training is focused on the individual rather than on the group. The instructor has become a manager and organizer of skill practice rather than a presenter of verbal instruction.

Ample evidence was obtained to confirm that institutional change in large organizations does not take place easily or quickly. While trainees adapt readily to this new system and find performance-oriented training both meaningful and motivating, the process of introducing change through training managers and instructors who are products of the "conventional" system takes time and effort. It is apparent that institutional change, if it is to occur and be maintained, requires supervision from training managers and commanders; hence, their behavior must change also.

It should also be apparent by now, that an undertaking such as ATC-PERFORM requires mutual understanding, cooperation, patience, and considerable tolerance for frustration among all participants—researchers, sponsors, instructional personnel, and trainees.

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THE ROLE OF SIMULATORS IN PILOT TRAINING: SOME QUESTIONS REGARDING EFFECTIVENESS

Paul W. Caro

Introduction

The use of simulators and other training devices* by the military has grown rapidly in recent years. Whether this phenomenon is attributable to the desire to improve training efficiency and effectiveness or to other causes is an open question. Following a study of the use of aircraft simulators in selected U.S. military and civilian pilot training programs, the Comptroller General of the United States recently issued a report to the Congress which was critical of the extent to which simulators are being used in the military training programs studied. (1) The report suggested that present knowledge of simulator design and employment is sufficient to support much more extensive use of simulators than was typically found to be the case. The report cites certain pilot training agencies which seem to employ that knowledge more effectively than do others, even though the knowledge is available to all.

The Comptroller General's report was not intended as a scientific study of psychological factors and their influences on simulator training effectiveness. Instead, it identified factors related to the management of simulator training and attitudes toward such training which tend to impede more extensive use of simulators. Factors identified include regulations emphasizing aircraft rather than simulator training, inadequate instructor training, failure to use simulator capabilities fully, and poor simulator maintenance. The influence of such management factors upon trainer use has been documented in the research literature. (2, 3) Other factors which have been identified as impediments to effective simulator use include the design of the simulators themselves and the design of the training programs in which the simulators are employed. (4, 5) Still other factors have been reported that influence the acceptance of simulators by those who must use them and thereby indirectly impede their more extensive use. (6)

Extensive use of simulators is not necessarily synonymous with effective training, however. In one study (7), it was found that the use of a particular device added cost, but no training value, to an already expensive pilot training program. Another study demonstrated that the training value of a device could be increased substantially without increasing the amount of device training time when the manner in which the device was used was changed. (8)

While there is a great deal of scientific and training literature in existence dealing with simulator training, some of the more significant factors influencing transfer of simulator training have not received the attention they warrant. The purpose of this paper is to call

*Many writers distinguish between simulators (e.g., " . . . a high degree of relevance to operational equipment . . .") and training devices (e.g., " . . . any piece of apparatus which is used for training . . ."). The present writer will treat these examples of training equipment as members of a single class. To quote Gagne (9, p. 96): "What distinguishes a training device (from other training equipment) is not its appearance or construction, but rather *how* and *for what purposes* it is used." The term simulator is used here to identify ground-based training equipment used for the purpose of training pilots to fly aircraft. The question of *how* it is used will be addressed in the paper.

attention to some of these factors and to note their impact on transfer effectiveness. The emphasis will be upon increasing the effectiveness of simulator training as opposed merely to increasing simulator use. While simulator effectiveness and use obviously are not independent (a simulator cannot be used effectively when it is used little or not at all), they are not always coincident. Some simulator designers and users appear unaware of factors which, if properly treated or managed, would markedly enhance the value and efficiency of simulator training programs. The unfortunate consequence of their lack of awareness is that simulator training effectiveness suffers: skills which may be critical to safe operation of an aircraft may not be developed, and aircraft scheduled for training purposes may be needed elsewhere.

Factors Influencing Simulator Training Effectiveness

A recent summary of simulator training studies (3) indicated that simulator training effectiveness has increased markedly since World War II. Some of the increase can be attributed to advances in engineering and instructional design technologies. Simulation engineers now have the technology available to build simulators which more nearly satisfy Thorndike's common elements design hypothesis, and instructional system designers have learned how to zero in on tasks to be trained. But much of the increase has come about as a result of research and experience with simulators in operational training settings.

In spite of the large number of simulator effectiveness studies that have been completed, there remains much to be learned about training with these devices. A number of factors have been nominated as influences upon simulator training effectiveness, but many of those nominations have been based on inference rather than experimental evidence. In their review of simulator research, Muckler, Nygaard, O'Kelley, and Williams (14) noted that many studies compound the influence of several potential influences (such as training program content, instructional technique, and instructor qualification) into a single independent variable so that the transfer effects can be attributed only to the unique combination of those influences. Even in the few experimental investigations which isolate assumed influences, the results must be interpreted cautiously because they address unique training requirements and have not been replicated.

The methodological problems involved in identifying factors which influence simulator training effectiveness cannot easily be overcome. Suspected factors can seldom be examined in isolation. It is difficult, for example, to determine experimentally the relative value of a remote instructor station vs. an on-board or in-the-cockpit station even if a suitably designed simulator were available for the research, because to use each station to its best advantage would necessitate having two methods of training: one optimized for remoted instruction; the other optimized for on-board instruction. The experiment would thus compare instructor station and training program combinations rather than a simulator design feature in isolation from other factors. The training program factor cannot be held constant. It would be inappropriate to compare two simulator designs using a program optimized for only one or for neither.

The problem of generalizable results is not limited to studies involving operational simulators. Even using equipment designed and dedicated to research, problems arise. For example, to pursue the illustration of instructor station location described above, simulator hardware inflexibility makes it difficult to conduct the necessary research leading to the design of the optimum remote instructor station for experimental comparison with the optimally designed on-board station. Additionally, the on-board station design which is optimum for a single-seat, high-performance attack aircraft simulator with a visual display may bear little resemblance to the optimized on-board station for undergraduate instrument training in a side-by-side seating helicopter simulator.

Definitive data do not exist which will permit the quantification of the influence of all factors believed to bear on simulator training effectiveness. In fact, the mere identification of most such factors rests upon inference, conjecture, and untested hypotheses. The absence of hard data obviously cannot justify suspected factors being ignored, however. Where inferences can be made and supported by consensus, factors believed to influence simulator training must be taken into account by those responsible for simulator design and use, unless evidence can be assembled to refute those inferences. It is the responsibility of the research community to undertake the systematic investigation of such factors.

The following discussion is intended to call attention to selected factors which influence simulator training effectiveness. It would not be fruitful to attempt to cite all the researchers who have contributed to the identification of such factors. Those who have contributed to the literature on physical vs. psychological variables in simulator design, for example, are legion, as are those who have remarked upon the importance of how the simulator is used. (Review articles touching on the subject include references 2, 3, 14, 15, and 16.) Except where reference is made to a particular report, the author acknowledges responsibility for the inferences set forth herein, as well as for the selection of factors to be discussed.

Simulator Design

There are two areas of interest with respect to the influences of simulator design upon transfer of training: fidelity of simulation and design for training. "Fidelity" refers to whether features of the aircraft and its environment are included in the simulator's design, and the extent to which features which are included represent or duplicate their real-world counterparts. "Design for training" refers to the inclusion in simulator design of features or configurations which facilitate training but which may bear no particular resemblance to features of the aircraft and environment being simulated.

Fidelity of a simulation is often equated with physical correspondence between the device and its real-world counterpart. In their discussion of simulator design considerations, however, Smode and Hall (17) emphasize instructional strategies and capabilities and suggest that fidelity has meaning in terms of the process and the realism necessary to promote learning. Design characteristics, they assert, should be defined in terms of assuring transfer of training. In other words, fidelity of simulation is a matter of the relevance of the simulation to the training objectives, not solely a matter of physical correspondence. This concept of fidelity accounts for the effectiveness of so-called low fidelity devices as well as simulators that faithfully reproduce much of the aircraft.

Design for Training. The Smode and Hall concept of fidelity is of particular interest with respect to simulator features not modeled after the aircraft. These features, which are concerned primarily with the application of learning principles to the training process, include freeze, adaptive training, prompting and cueing, performance recording and playback, performance measurement, and various instructor station displays and controls. It is generally held that such features improve the conditions under which learning takes place and thereby facilitate the attainment of training objectives. Therefore, they are factors to be considered in judging the fidelity of a device so far as training is concerned.

It is general practice to adopt innovative simulator design features, such as those mentioned above, on the basis of their apparent utility without subjecting them to experimental scrutiny. For example, the widely used simulator freeze feature was implemented because it was seen as an aid to attaining training objectives and to implementing learning concepts during the instructional process. Similarly, other design decisions are made because the training objectives and planned concepts of simulator employment lead to the conclusion that a particular design is appropriate in preference to others. For example, in the design of U.S. Army simulators for the Vertol CH-47 and the Bell AH-1 helicopters, the instructor stations were located virtually inside the cockpits of these devices, and certain instructor displays were positioned so that they could be viewed by both the instructor and the trainees in order to facilitate instructor-trainee interactions during key training activities. The training effectiveness of these features probably will never be determined in a transfer experiment for reasons advanced elsewhere. (See Jeantheau (10), Meister, *et al.* (11), and Adams and McAbee (12), for example.) Analytically, they are believed to represent effective simulator designs with respect to the Army's training program and the training objectives to be addressed.

Visual Fidelity. Generally, tasks which cannot be duplicated or even approximated in a device cannot be learned there for subsequent transfer to the aircraft. Therefore, a simulator in which more tasks characterizing flying can be performed has greater potential training effectiveness than one in which fewer such tasks can be performed. For example, a simulator which does not include an extra-cockpit visual display would seem to have less effectiveness potential with respect to training tasks requiring visual references than a simulator with such a display.

There have been a number of studies in which transfer from a simulator with a visual display has been demonstrated. The scenes presented by some of these displays are much simpler than scenes viewed from an aircraft. For example, savings in aircraft time required to perform visual reference maneuvers were demonstrated in a study by Flexman, Matheny, and Brown (18) using a simulator with a visual display consisting of a line drawing on a blackboard placed in front of the cockpit and tilted by an instructor to change the perspective as the device was maneuvered with respect to simulated ground references. The effectiveness of other simple displays consisting of stylized grids and lines has been demonstrated in backward transfer situations during studies of contact analog displays developed for helicopters. (19) Displacement of scene elements consisting only of dots and lines was found by Thielges and Matheny (20) to provide sufficient information for the performance of aircraft control tasks, although their study was not based on a transfer model.

These studies indicated that tasks involving aircraft control in relation to extra-cockpit visual information can be practiced effectively in simulators with very simple visual scene displays. The displays consisted of no more than points, lines and geometric patterns arranged in accord with a set of mathematical relationships described by Gibson. (21) Several manufacturers currently are taking advantage of the utility of these simple scene content design requirements by marketing displays which represent night scenes as patterned points of light on a black field, and their displays are being used with apparent success in commercial airlines' simulator training programs.

While the effectiveness of such simple visual displays has been demonstrated to the extent described above, it is also noted that simulators without a visual display can be effective in the training of visual reference flight tasks. In a study involving a helicopter simulator without a display or any other representation of outside visual cues except the aircraft's navigation and attitude instruments, and without any attention during simulator training to extra-cockpit visual cues *per se*, students trained to fly instrument flight missions in the device qualified in the aircraft under visual conditions more rapidly than did students not receiving the prior device training. (22) In a similar study using a fixed wing simulator without a visual display, a saving in visual flight time required to complete a transition course of approximately 50% of the scheduled course length was obtained. (8) An unreported study by the U.S. Air Force involving cognitive training in a simulator with no visual display demonstrated transfer to visual flying maneuvers such as traffic patterns. (23)

While it is not indicated by these studies' results that visual displays have no training value, it appears that many behaviors required as responses to extra-cockpit visual stimuli in the aircraft can be practiced, or at least approximated, in response to stimuli in a simulator without an outside display. Further, cockpit instruments provide information about, and an analog display of, the visual world outside the cockpit, so that a pilot flying instruments is responding to stimuli analogous to those available to the pilot flying visually. At least some of the simulator effectiveness attributed to the simpler visual displays probably would occur without the presence of such a display at all.

During the current review, no studies were found which unequivocably established the effectiveness of any extra-cockpit visual display. While transfer studies involving visual displays were found, only one, an exploratory study judged inconclusive by its authors (24), included a control group in which students were trained in the simulator without using its display. Commercial airlines have reduced aircraft training time following the addition of a visual display to an existing simulator, but some if not all of the reduction resulted from *a priori* judgments by government agencies and the airlines themselves concerning increased simulator training effectiveness. In no cases have there been reports of efforts to design training programs that would seek the same flight training savings using simulators without visual displays that presumably have been achieved using simulators with such displays.

The lack of evidence of visual display training effectiveness cannot be taken as evidence of their lack of effectiveness. There is a consensus that they are effective, and data to contest that consensus do not exist. Logically, it would appear that an extra-cockpit visual display is an effective way to present visual information used in some operational tasks, such as landing on a carrier, taxiing, refueling, delivering certain kinds of weapons, and air-to-air combat. In some instances, it may be the only effective way. In others, it may be effective but inefficient, particularly when cost is taken into consideration.

Motion Fidelity. Not much more is known about the influence of motion upon simulator training effectiveness than about visual displays. Although motion simulation has represented a significant portion of the cost of simulator procurement and operation for a number of years, the investigation of the influence of motion upon simulator training effectiveness has been largely ignored. The first significant study involving simulator motion in the transfer of pilot training was reported in 1975 by Jacobs and Roscoe. (25) The results of the Jacobs and Roscoe study provide evidence that transfer may not benefit from the presence of normal washout cockpit motion. In that study, training received in a two-axis normal washout motion condition, compared with training in the same device without motion, resulted in nonsignificant differences in amount of transfer to the aircraft for these two conditions. There was however, significant positive transfer for both motion and no-motion conditions. Similar results have been obtained in an unpublished U.S. Air Force undergraduate pilot training study involving a more sophisticated six-axis motion system. (23)

The Jacobs and Roscoe finding (that, at least with beginning trainees, the presence of motion may not increase simulator training effectiveness) must be treated with caution until investigated further, since there are other studies suggesting that, at least under some circumstances, motion may be desirable even if not essential. For example, Fedderson (26) reported a slight advantage in favor of a motion-simulator trained group over a no-motion group during brief transfer trials hovering a helicopter. More importantly, perhaps, the motion group in his study reached asymptotic performance in the simulator more rapidly, suggesting that simulators with motion may provide more efficient training, even if not more effective training. NASA researchers (27) have found that the correlation between pilot performance in an aircraft and in a simulator increases with the addition of simulator motion cues, where such cues help the pilot in coping with a highly damped or unstable vehicle or a sluggish control system or, under some circumstances, where the control system is too sensitive. Where the aircraft is easy to fly, however, as is the case with the aircraft used in the Jacobs and Roscoe study (Piper Cherokee) and in the Air Force study (T-37), motion has no effect. In another NASA study (28) of the effects of simulator motion on pilots' performance of a tracking task, the results from a moving flight simulator resembled the results from flight much more than did those from a motionless simulator. Huddleston and Rolfe (29) reported that, using simulators without motion, experienced pilots are often able to achieve acceptable levels of performance, but their patterns of control response show that their performance is achieved using a strategy different from that used in a dynamic training environment. Since control strategies may be important during inflight emergency maneuvers where transfer of training research is not feasible, it would appear inadvisable to eliminate motion from all simulators until further investigation shows the generality of the Jacobs and Roscoe findings. At the present time, we cannot be certain of the role of motion in simulator training effectiveness and efficiency.

Handling Characteristics. Simulators built with the technology available two decades ago tended to have handling characteristics which were sometimes quite unlike those of an aircraft, and their effectiveness was limited largely by the fact that pilots resisted training in them or would use them only as procedures trainers. (5) There were—and still are—strong pilot opinions that a simulator had to "feel" like an aircraft if it were to be effective. Transfer studies of individual aircraft control parameters, such as a study of the correspondence in stick pressures between a device and a training aircraft (30), failed to lend support to the pilots' opinions. Where the correspondence between the device and the aircraft is gross, as was found in one device in which forward pressure on the wheel resulted in a climb configuration (31), simulator effectiveness undoubtedly will suffer. Thus, except for the extreme case wherein simulator response characteristics unlike those of the aircraft can produce negative transfer of training, there is little evidence that the simulator must precisely duplicate the feel of the aircraft in order to be effective. It is possible, however, that even minor dissimilarities in feel or response could lead to the same kinds of potential problems found in simulators without motion, i.e., lower correlation between simulator and flight performance, particularly where the more difficult to fly aircraft are concerned.

Our understanding of simulator design features in relation to simulator training effectiveness is quite limited. It is clear that designing a simulator is not entirely a matter of duplicating an aircraft. The physical correspondence between the simulator and the aircraft is probably more related to cost, as Miller (32) indicated almost two decades ago, than to training effectiveness. If the degree of correspondence between the device and the aircraft is relevant to the objectives of the intended training, training in the simulator can be made effective. Whether it is effective or not is a matter related to other factors.

Training Problems

Frequent note has been taken of the influence upon training effectiveness of the manner in which a simulator is used. Yet, the literature is full of reports of situations in which the importance of training program design and execution seemed to be ignored. (See reference (5), for example.) Although there is an increasing emphasis upon effective use of devices, current instances can be cited of training programs in which simulators are misused or are used inefficiently. Even in simulator effectiveness research, participating instructors often are permitted to conduct training in various non-standardized ways.

To list all training program design and execution variables which potentially influence simulator training effectiveness would be an almost interminable task. Any of the numerous textbooks on human learning will provide a source for identification of variables which influence learning and performance, e.g., schedules of reinforcement, meaningfulness and difficulty of material to be learned, size of learning blocks, and knowledge of results. Flexman, *et al.* (18) have shown how such variables can be employed to increase simulator and flight training effectiveness.

The sequencing of simulator and aircraft training has been suggested as a factor which could influence the effectiveness of simulator training. Smode, *et al.* (2) concluded that the evidence concerning whether sequencing is influential was inconclusive. Meister, *et al.* (11) presented data which suggest that switching from the aircraft to the simulator reduces performance in the simulator on the following sessions, resulting in a training inefficiency. While there may be some interactive effects between the sequence, the manner in which the device is used, and the design of the device which could influence effectiveness, it would appear quite likely that training in the aircraft before the full benefit of the simulator has been realized with respect to a particular task would tend to reduce the overall efficiency of the simulator-device training program. In an unpublished instance that illustrates this view, a fifty-training-hour program in which the simulator was used prior to training in the aircraft became a sixty-training-hour program when the sequence was changed to mix simulator and aircraft training, although other changes were introduced concurrently which could have contributed in the resulting inefficiency.

Training program content is an obvious influence upon simulator training effectiveness. A dynamic flight simulator used only as a procedures trainer, for example, is not being used effectively. It is also believed that simulator training presented in the context of simulated mission activities, as opposed to abstract training exercises, tends to be more effective, and the literature on learning and forgetting suggests that behavior learned within such a meaningful context will be less quickly forgotten. (33)

There are a number of other training program factors which influence simulator training efficiency and thus would lead to a higher TER value, although not to increased effectiveness *per se.* These factors include the amount of simulator training, the sequence in which instruction is conducted in the simulator, the use of individual (as opposed to group) pacing, training to specified criterion levels (as opposed to training for fixed time periods), and the extent to which simulator training includes tasks which can be learned more efficiently in the aircraft. Smode, *et al.* (2) pointed out a decade ago that little was known about how to manipulate such factors to best advantage. That observation is still valid.

Personnel

Simulator training involves trainees and instructors. Both categories of personnel represent potential influences upon effectiveness. The most obviously relevant considerations with respect to both are their qualifications and prior experience, but occasionally other variables are suggested. For example, Meister, *et al.* (11) found a difference in the effectiveness of one simulator training program for student and operational pilots vs. reservists. The difference could also be attributed to considerations such as fatigue and stress, factors which probably account for many unexpected findings in transfer studies. The present paper will discuss only the more obvious personnel factors.

Trainees. All investigations of human learning are subject to the influences of task-related aptitudes of the learners. Aptitudes are defined in terms of learning efficiency, and high-aptitude students learn a given task more rapidly or to a greater degree than do low-aptitude students. Where the training program involves fixed amounts of simulator training time, high-aptitude students learn more tasks to transfer to the aircraft; where training is to fixed performance levels and training time varies, high- and low-aptitude students achieve about equally, but high-aptitude students require less training time in the simulator. A measure of simulator training efficiency, such as the TER, will yield a higher value for high-aptitude students, but this does not indicate that the simulator training program is more effective with such students. It is probably equally effective with both groups of students, but training time in the device will be shorter for one than for the other. Thus, while high-aptitude students learn more efficiently, aptitude *per se* is not believed to be an influence upon simulator training effectiveness.

The influence upon simulator training effectiveness of level of trainee skill or amount of prior flight experience is frequently questioned. Many military pilots and managers acknowledge that simulators provide appropriate training for the airlines, where the trainees are highly experienced, but insist that the devices cannot be relied upon as extensively to train less experienced military pilots. The skills possessed by these two groups of trainees do differ, qualitatively as well as quantitatively, and the tasks for which they undergo training are not identical. Therefore, the training they receive should not be identical if it is optimally designed to meet their respective training needs, and the characteristics of the simulators involved in their training should vary as well. It does not follow, however, that simulator training can be appropriately designed and conducted for one experience level trainee but not for another. In fact, the experimental evidence does not support the contention that simulator training effectiveness is influenced by level of trainee experience in isolation from other factors. After reviewing a large number of transfer of training studies, Micheli (3) concluded that flight training devices are effective for both neophyte pilot trainees and experienced airline pilots.

Instructors. After reviewing the literature on the flight instructor, Smode, *et al.* (2) concluded that experienced pilots do not make better inflight instructors than inexperienced pilots. The same conclusion can be extrapolated to simulator instructors. While the evidence is skimpy, it appears that even personnel with no flight experience can be trained to be effective simulator instructors. For example, in a simulator training study comparing an instructor with several thousand hours military instructor-pilot experience, a recent flight training program graduate, and a non-rated individual with a few hours dual instruction but no other aeronautical experience, no significant differences were found in the in-flight performance of their students. (34)

There is some evidence that not all simulator instructors are equally prepared for their job. Hall, *et al.* (5) surveyed a number of military training programs and found that non-rated enlisted instructors were ill-prepared as compared with pilots, particularly with respect to relevant knowledge of the aircraft. They also noted that pilots were similarly ill-prepared with respect to knowledge of the capabilities and limitations of the simulators. Since no transfer data were reported, it cannot be determined whether this factor had an influence upon subsequent in-flight performance in favor of either type of instructor.

Muckler, *et al.* (14) observed that in some cases a simulator instructor must provide supplementary information about the in-flight task which might not be available to a non-rated instructor, thus presumably tipping the scale in favor of pilots as simulator instructors. Muckler, *et al.*, also noted that instructor ability and fidelity of simulation are related in such fashion that as fidelity increases, the necessary level of instructor ability may decrease, and, conversely, as fidelity decreases, instructor ability must increase. This relationship would tend to place the more able instructor in the lower fidelity simulator where a greater amount of supplementary information might be required. It has been my observation that just the opposite situation often obtains. The more experienced pilots instruct in high fidelity simulators, while less experienced and non-rated personnel instruct in older, lower fidelity devices.

Another consideration is whether there should be one instructor or two in a simulator training program. That is, is simulator training effectiveness influenced by whether the simulator instructor is also the in-flight instructor? While this variable has not been isolated for study, there appears to be an increase in effectiveness when a single instructor is responsible for both simulator and aircraft training, and it has become a standard feature of the simulator training programs developed by my organization.* One apparent benefit is that the instruction given in the simulator is more compatible with that given in the aircraft when only one instructor is involved, thus reducing any potential negative transfer attributable to instructor-peculiar performance requirements.

It often has been assumed that the instructor is an important factor influencing training effectiveness, and such may well be the case. If so, the influence must be

*The single instructor concept has been used elsewhere, at least as early as the late 1940s. (35)

attributable to the manner in which the instructor functions, i.e., to non-standardization in his administration of the training program. There is insufficient evidence available at this time to attribute the assumed influence to instructor experience or qualification *per se*, assuming he has undergone an instructor training program appropriate to the instructional task at hand.

Attitudes

While the influence of simulator design upon simulator training effectiveness may not always be clear, simulator design has an impact upon instructors and trainees, reflected in their attitudes, which in turn has a great influence upon simulator training effectiveness. Flexman described this impact as follows (14, p. 69): "Fidelity of simulation can operate as a motivational variable. If the simulator looks, acts, feels and sounds like the airplane, then the trainee is more likely to be convinced that practice in the device will be beneficial to him." In circular fashion, attitudes also influence simulator design. Williges, *et al.* (16) noted this phenomenon when they stated that decisions to include complex and expensive motion systems in simulators are invariably determined by pilots' attitudes. It has been my observation that fidelity of simulation has a greater impact upon the attitude of the simulator instructor, particularly if he is a pilot, than it has upon the trainee, and, in turn, instructor attitudes concerning simulator training can determine trainee attitudes.

The most direct effect of trainee and instructor attitude upon simulator training effectiveness is probably upon their willingness to engage in simulator training in the first place. That is, devices which are viewed favorably seem to be used more than those which are viewed less favorably. If the addition of a motion system or visual display to a simulator will result in favorable trainee and instructor attitudes toward simulator training and hence greater utilization of the device, it is possible that more effective simulator training will result from the greater utilization, even though the motion and visual *per se* may contribute nothing directly to the transfer.

It would be a mistake to attribute all favorable attitudes toward simulator training to high fidelity. There are relatively low fidelity devices which are viewed favorably by many trainees and instructors, and some quite sophisticated devices have been maligned unbearably by some of the same people. One device used extensively by the U.S. Army as an instrument trainer for a number of years was extolled by the device instructors, maligned by flight instructors, and described variously as "a beast" and "an aid" by trainees. A study of the effectiveness of training conducted in the device was less ambiguous: it was useless. (7)

Except to the extent that favorable attitudes increase device use, the effects of attitude upon simulator training appear to be practically nil. In a study reported by Muckler, *et al.* (14), negative attitudes toward a trainer were induced in an experimental group by stressing the device's low fidelity, while positive attitudes were induced in another group by stressing the same device's training effectiveness. During transfer trials in the aircraft, both groups were found to have benefited, about equally, from the device training, thus indicating that the induced negative attitude did not affect device training effectiveness. An interesting aspect of that study was that the negative attitude group required more training in the device to reach criterion, so that the TER value, had that measure of effectiveness been used, would have been greater for the positive attitude group.

No transfer study was found during the current review which indicated that attitude *per se* was a factor influencing simulator effectiveness. On the basis of my own experience, it appears that just the reverse may be the case: simulator training effectiveness influences attitudes toward simulator training. I have observed abrupt shifts in attitudes, particularly among instructors and training program managers, following demonstrations of simulator effectiveness. In one instance, instructors' very negative attitudes toward reduced scale paper mockups of a cockpit became favorable when they discovered that, unknown to them, their better students were using these "devices" on their own. In a study reported by Meyer, *et al.* (4), pilots' opinions concerning simulator training were found to be more favorable following their participation in an effective simulator training program than were the opinions of non-participating pilots.

In spite of a lack of supporting research evidence, there is a consensus among trainees, instructors, and administrators that favorable attitudes toward simulator training increase training effectiveness. This probably is correct in the sense that more extensive use will be made of simulators if they are viewed favorably. It may be, however, that attitudes are influenced more by simulator training effectiveness, than the other way around. A well conducted "test" of the training effectiveness of a simulator may be a very influential factor in assuring that its training value will be realized.

Expectations

Many aviators accept the proposition that training in a simulator might be helpful, but view it as less effective than training in an aircraft. It has been my observation that simulator training administered under the control of such individuals never exceed their expectations. If simulators are viewed as useful only as procedures trainers or as instrument trainers, they tend to be used only as procedures or instrument trainers, even though the same devices might be used more effectively by others who view them as offering a greater range of training opportunities. If simulators are viewed as useful only for the initial stages of the development of a particular skill, to be followed by further development of that skill in the aircraft, simulator training is less effective than if they are viewed as substitutes for the aircraft to be used for the development of a particular skill to criterion before transferring to the aircraft. While simulator training may not always prove as effective as some might expect, expectations appear to place a limit upon realized effectiveness by limiting the manner and extent of simulator training.

Expectations can influence simulator training effectiveness in more subtle ways as well. The expectation that a simulator training program will prove ineffective can influence its evaluation in the expected direction. Research by Rosenthal (36) has shown that, even with no intention to do so, an experimenter influences the outcome of his research in the direction of his expectations. Since many "tests" of the effectiveness of simulator training are conducted by pilots who hold strong views concerning the value of simulator vs. aircraft training, we must assume that their expectations can and sometimes do influence the test data. In those instances in which there is real or perceived pressure from a higher authority to reach a particular finding concerning the utility of a particular simulator, the effect might be even greater.

There is an almost infinite number of factors which might shape expectations concerning simulator training effectiveness. An obvious factor is prior experience with simulator training. The more favorable opinions of pilots toward simulators following participation in an effective simulator training program were noted above. Another factor may be their age. Smode, *et al.* (2) noted that older pilots tend to make poorer flight instructors, possibly because of a hesitancy to adopt new teaching methods such as the use of simulation. Total flight time is probably also a factor, since the older, more experienced pilots are more likely to have had unsatisfactory experiences with old simulators and typically put greater confidence in in-flight training.

Increasing Simulator Training Effectiveness

It is unlikely that the effectiveness of any simulator training program can be attributed to a single influence. Instead, all the factors discussed above, and probably many more subtle ones, act in combination to produce effective simulator training. Even factors which may not be thought influential in isolation may serve as catalysts. Effective simulator training depends upon a proper combination of hardware, program, personnel, and other factors.

Although progress has been made over the four decades since Edwin Link introduced his first instrument flight trainers, there is still an element of uncertainity involved in the design and use of simulators in meeting training objectives. Wheaton and Mirabella (37) noted that simulator designers have often been more artisans than technicians, and because of the informal nature of the methods they use, it is difficult to reproduce their results or to train others to produce effective devices. The same comment can be applied to training program developers, perhaps to an even greater degree. There are artisans who devise effective ways of using simulators, even apparently poorly designed simulators, but these artisans have not been notably successful in training others to produce effective simulator training programs. Conversely, it can be noted that others have produced precious little in the way of effectiveness, even though working with costly simulators of apparently excellent design.

While simulator training artisans can sometimes produce spectacular results, there are too few such individuals to develop and continuously update all of the simulator training programs required by military and civilian pilot training establishments and operational units. The present paper was conceived as an attempt to highlight some considerations which, if attended to, might lead to increases in simulator training effectiveness. It may have that effect in some instances, but I am not convinced that our present data base is sufficient to that objective.

Clearly, more research is needed to increase our understanding of factors influencing simulator training effectiveness. But a conceptual framework which could make the conduct of that research more efficient and relevant to generalizable problem solutions is lacking. Because of this lack, training specialists have no theoretically acceptable design models to follow and no effectiveness goals to seek. I do not see much in the recent research literature which will provide the conceptual underpinning for required simulator training designs.

One problem is that insufficient information is being disseminated about the design of simulators and training programs, both effective and ineffective ones. Most published simulator training research reports state the identity of the simulator, the experimental design model, and the results. Often information is not included in the report or otherwise available about the simulator's design, the way it was used, the attitudes and expectations of the personnel involved, and other factors which should be of interest to someone trying to apply the study's results to meet operational training requirements. There needs to be much more emphasis upon *how* the reported results were achieved.

Attempts to apply research results in the design of simulators and training programs are important, but greater benefit can be derived from study of existing devices and programs to locate features which can be adopted in new simulator training programs under development. The most useful model to follow in the development of effective simulator training is that provided by an existing application, modified to incorporate features from other such models as seems appropriate.

The simulator training practitioners and researchers alike need more case study reports of simulator training applications. Such case studies would serve two purposes: they would provide models to be followed in other applications; and they would present design data which could then be assembled and studied in efforts to develop conceptual models for future applications and to guide research.

While I do not mean to relegate research to a lesser position of importance in our efforts to increase simulator training effectiveness, I feel that there needs to be more emphasis at the present time upon gathering data about existing simulators and training programs so that a better conceptual framework can be developed for such research. Our theories need to rest upon a broader data base—data which is derivable from present applications. At the present time, there needs to be more use of the scientific method called "naturalistic observation" so that a broader data base can be developed. Perhaps the first step is to recognize a need for better communication among practitioners and researchers about the nature of effective simulator training. Such a step could lead to increased simulator training effectiveness through greater familiarity with the processes involved in simulator training.

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