



A 50+ Year Search for Effective, Efficient and Engaging Instruction

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In this paper I will chronicle my 50+ year career, from my interest in making education more effective, to an epiphany about theories, and some of my published work that, for a time, gained the attention of others in the field of instructional technology. My extensive experience with computer-assisted learning covers early efforts to teach concepts to attempts to design automated authoring systems. My most recent work attempts to identify

underlying principles common to most theories of instruction.

The professional press publishes reports of theory, research, data, prescriptions, and opinions, but seldom do we get the back story. Where did these ideas originate? What events led to a particular theoretical or research approach? What were the challenges—personal and interpersonal—that affected a given approach, theory or research study? In this paper, in addition to identifying a few of the most notable contributions to this literature, I will provide some of the back story that contributed to my career and inspired or significantly influenced my work. I will also highlight some of the lessons learned along the way.

This paper is an unapologetically autobiographical account of my career. Perhaps my personal quest for understanding the nature of instruction will be instructive to those who are also pursuing this important question. While I have learned much I have also realized that there is much more to learn. If I had a wish, it would be to be able to begin my career again while retaining what I have learned.

You Only Need Three Crayons!

My father was an artist—a landscape painter. As a small boy I wanted to be an artist like my father. I thought that if I could just have a large box of Crayola Crayons, I would be able to paint beautiful landscapes like my father. For every birthday, I would request a large box of crayons. I was unaware of the precarious financial affairs of my parents. My dad never said they couldn't afford a large box of crayons. He merely sat down with three crayons – red, yellow, and blue – and a piece of paper and colored a



beautiful landscape. By example, he taught me the primary colors and mixing pigments. For my birthday I would get a box of 8 Crayola Crayons. My dad would point out that I had more crayons than I needed to paint beautiful landscapes. I didn't become an artist, but I never forgot my primary colors and how to combine them to get all the colors of the rainbow. Latter in my career, as I'll describe below, I remembered that you only need three crayons.

Lesson 1. A few simple elements can be combined into complex outcomes.

Mormon Missionary 1957-1959

My career in education had its origin in my missionary experiences for the Mormon Church. Like many young men in our society at the age of 20 I was called to serve two years sharing information about the founding and doctrines of the church. My field of labor was not some foreign country but here in the United States in the states of Indiana, Ohio and Michigan. In those days our approach was to go door to door, introduce ourselves and try to set up an appointment to come back and teach some simple lessons about the founding and doctrine of the church. I'll never forget the day during the first week of my mission that marks the beginning of my educational career. It was my companion's turn to make the approach because I was still a "greenie". A gentleman opened the door and my companion introduced us as representatives of the Church of Jesus Christ of Latter-Day Saints. Then he gave our usual introduction: "Mr. Brown have you ever wondered why

there are so many different churches in the world today?"

"I've never thought about it in my whole life!" was his gruff reply.

"Well just like you", my companion continued, "many people have had this important questions."

Mr. Brown shut the door. I was in shock! Why did my companion continue with our canned dialogue when it was obvious that Mr. Brown had no interest in this question? There had to be a better way to teach than this. I spent much of the rest of my two years as a missionary studying and trying to help other missionaries be more effective teachers. My attempts as a very young man were very primitive but they created a burning desire to find out how we could make our teaching more effective and engaging.

Lesson 2. Don't hesitate to try to find a better way even for well established procedures.



Brigham Young University 1959-1961

You Could Make a Difference!

Prior to my mission I had pursued a course in electrical engineering. My grades in physics, chemistry, and calculus were less than inspiring, and based on my missionary experiences I decided to pursue a career in secondary education. I must confess that the education courses I pursued were very disappointing. I wanted to learn how to make a lesson effective and engaging but

instead I learned about school law and how to avoid getting sued, an even more important skill in today's schools, but it did not contribute to my understanding of effective teaching. I also learned how to pass out papers to avoid confusion, I created a resource file which I never again opened and finally discarded years later. I had a wonderful time in my student teaching. I was assigned to teach American History and Reading even though my major was psychology and mathematics. The principal did not find my very unconventional approach to teaching consistent with his expectations and he threatened to fire me twice during the 6 weeks of this experience, once for holding a political rally in my class (this was during the Kennedy-Nixon election year) and once for having the students read the communist manifesto and compare it to the constitution, both of which I thought were great ideas for my students.

Since my classes were very disappointing and not giving me any of the skills I thought I needed to be a more effective teacher, and since it was pretty obvious that my entrepreneurial approach to teaching was obviously not going to endear me to the public schools, I decided that I had made a mistake and that I better find another career. I expressed my displeasure and decision to change careers to Asahel Woodruff, one of the professors whose work I did find valuable. He validated my concerns but suggested that instead of giving up, that I should go to graduate school, get an advanced degree, and see if I couldn't be an agent of change in education. Not being one to shy away from a challenge, after he assured me that there were PhD programs that I could enter directly from my bachelor's program, and that many had generous scholarships or fellowships that would pay for my education, I decided to pursue a PhD. He recommended several possible programs, I applied to three and was fortunately accepted in all three and chose to pursue a PhD at the University of

Illinois and was offered a full-ride 3-year fellowship that would cover all of my expenses. This was probably the wrong reason for choosing a graduate school but serendipity prevailed and I was privileged to work with some of the most outstanding professors in educational psychology.

Lesson 3. Obstacles are often the doorway to greater opportunity.

An Oar and a Rubber Boot

In my final semester of undergraduate work, a check with the registrar showed that I was short one hour of credit for my minor in mathematics. Naturally there was no one-hour math class, so it was necessary to enroll in a three-hour class. The University of Illinois had already awarded me a fellowship for my PhD study, therefore the completion of the additional math class assumed considerable significance for my future. A class in number theory appeared, on the surface, to be the easiest path to the necessary credit. The year was 1961. New mathematics in the public schools was still in the future. Computers were just coming on the scene. Binary arithmetic, base 8, base 16, and other representations of numbers were not in the repertoire of a small-town undergraduate student scrambling to complete his bachelor's degree.

This particular class in number theory was, for this student, a unique math class: no problems to work, no homework, a very small textbook. At the end of each lecture the professor merely said, "Think about it!" Think about what? How do you think about mathematics? In desperation, and as a substitute for thinking, I read the textbook every week. It wasn't difficult; it had only 97 pages and a bright yellow cover. However, the concepts presented floated over my head like clouds in the sky. I had no idea what the course was about or what the text was about. Each week we had another lecture, the injunction to "Think about it!" and another read through of the text.

The midterm exam was a disaster. It had no problems to work, only a single question: "Invent a number system." Invent a number system? What in the world does that mean? In true survival mode I wrote for the whole two hours. However, it didn't fool the professor. There were seven students in the class; there were seven F's on the midterms. When we objected, the only explanation from the professor was, "Think about it!"

My anxiety was at an all-time high. My graduate career was about to be terminated before it began by the unnerving command, "Think about it!" I tried every avenue of escape: Another class? Getting the registrar to waive the credit? Home study? There were no other options. My bachelor's degree, and hence my entrance to graduate school, were both riding on a class in which I had received a failing grade on the midterm and, worse, a class that was to me completely incomprehensible.

Somewhere in the thirteenth week the light came on. Number systems are inventions. They are not natural phenomena. Number systems are like any other invention: an assembly line, an organization. A number system is merely a system of logic consisting of premises and conclusions. Base 10 is only one of many possible number systems. Base 10 numbers are useful for many everyday things, but other systems might be equally useful.

The day of the final arrived. My anxiety was still high, but at least I thought I understood. You guessed it, only one question, "Invent a number system." Either I understood or it was too late. My future graduate studies depended on my ability to invent a number system. So I wrote, "Let there be an oar and a rubber boot." I proceeded to define a binary number system with two elements, an oar and a rubber boot. I was in the professor's office the next day to see if I was going to graduate school or not. He handed me my paper with a large red *A* written across the top. I thanked him, breathed a sigh of relief, and vowed to never take another math class as long as I lived.

Lesson 4. Theories are merely attempts to find meaning in the real world but are, of themselves, not the real world.

University of Illinois 1961-1964

After a search I finally located the seminar room on the top floor of the psychology building. In length and breadth, it was not a large room, however the ceiling was perhaps 25 feet above the floor. High on the outside wall a dormer window allowed the warm Midwestern sun to stream into the upper corners of the room. In the center of the room 12 wooden chairs surrounded a large conference table. The hour to start had arrived and 6 students were already seated around the table.

At 5 minutes past the hour the professor entered and seated himself at the head of the table. He immediately removed a pipe from his inner coat pocket and from his jacket pocket removed a tool resembling a Swiss army knife on steroids and a packet of tobacco. Being a nonsmoker I found the ensuing ritual of scraping, cleaning, and tapping fascinating.

Movement in the corner of my vision distracted my attention from the ceremony at the head of the table and my gaze scanned around the table. To my astonishment each student around the table was holding a pipe and intently engaged in scraping, cleaning, and tapping with their own set of shiny tools.

At the conclusion of the cleaning ritual the professor carefully placed a pinch of tobacco in the bowl of his pipe. Each student in the room placed tobacco in his pipe like reflections in a house of mirrors. A lighter ignited the professor's pipe and six lighters flashed in response. Large spirals of blue smoke rose lazily toward the streaks of sunlight in the upper portion of the room. Soon the room was engulfed in a fog of blue haze. Odors both sweet and pungent permeated the air. The professor tilted his chair and placed both feet on the table. Six pairs of shoes joined his. As I stared at the soles of the shoes a voice from the haze

intoned, "Welcome to Experimental Psychology."

My first class in graduate school had commenced.



Training Research Laboratory

Serendipity has played a major role in my career. It has often been my good fortune to be in the right place at the right time. Entering graduate school was no exception. Upon entering the University of Illinois, Larry Stolurow was assigned as my temporary advisor. It would be better if this choice had been a result of my homework about his work prior to my entry in graduate school. But alas, it was not. But what a great opportunity was provided to me by Dr. Stolurow, providence, and an excess of good fortune. At my request he became the chairman of my PhD committee and the advisor for my PhD dissertation.

Entering the Training Research Laboratory for the first time was a surreal experience. The laboratory was located in the psychology building. But there was no number for the office, merely the designation *basement*. It took some time to locate the stairway to the basement. "This

certainly can't be the correct stair way", I thought. It looked like the way to a storage room. Descending the stairs, I was confronted with an unfinished basement with heating pipes overhead only about 5 1/2 feet above the floor. "Surely I've come down the wrong stairs." I returned to the main floor. But a long search revealed no other stairs descending to the basement. It is not a male characteristic to ask directions, but overcoming my natural inclination I went into the psychology office on the main floor and inquired after the Training Research Laboratory. To my surprise the secretary at the desk directed me to the same stairway that I had recently explored. "But," I protested, "this stairway leads only to an unfinished basement."

"Oh," she explained, "you must walk across the unfinished space to the south side of the building. There you will find a door that enters the Laboratory."

Once again I ventured to the dark space at the bottom of the stair. I bravely ducked under the heating pipes and made my way across the basement. There, as she predicted, I found a door with a small sign that said *Training Research Laboratory*. Timidly I opened the door and was warmly greeted by the secretary of the Lab. To my surprise the laboratory was nicely finished and furnished. There were no windows, but the lab was large with a number of offices and working spaces. The secretary directed me to my office where I was to spend the next 3 years.

I don't remember very many of my classes. Some of the professors were memorable, but the content of the classes has faded with the years. On the other hand, the memories of the Training Research Laboratory are as clear as if they happened only yesterday. My fellowship forbade my employment as a research assistant. This requirement had the great advantage of me being able to pick and choose those research activities I desired. At an early meeting Dr. Stolurow described a proposal for the National Science Foundation to obtain a

computer that we could use for Computer-Based-Instruction. This was 1961. Computers were still very new on the scene. Computer-based-instruction was unheard of. Together with my fellow students we reviewed the proposal. We had lots of brainstorming sessions about how to present our ideas so the reviewers at NSF would not reject them as crazy. It was a significant learning experience. Needless to say we all had a vested interest to see if the proposal would be funded. It was.

The funded proposal enabled the TRL to obtain our own computer for research on computer-based-instruction. The computer was an IBM 1620. The machine was designed to monitor oil refineries. No one prior to TRL had used this computer to control instruction. Under the direction of Dr. Stolurow we managed to attach this computer to a rear projection teaching machine. This concoction was named SOCRATES¹. This machine presented material like a microfilm reader but buttons on the front enables the film to move an odd number of frames forward, 1 – 15 frames, and 17 frames backward. The computer was inserted into the mechanism that moved the film so that instead of the buttons controlling the number of frames that the film moved the computer could control this branching so that any button could allow the film train to move any of the 16 possible moves. This enables us to create branching computer-based instruction.

I used this teaching machine for my dissertation which studied variations in providing feedback to students based on their responses that were indicated by the buttons they choose on SOCRATES. I had 12 different treatments that varied the type and amount of feedback provided. My dissertation was the first study that used this machine for research and I was able to

publish a couple of research papers in referred journals reporting this research.

My research involved teaching an imaginary science that was invented by one of my professors, Carl Bereiter. Since, except for some arithmetic, students had no experience with this subject matter content I chose it as a vehicle to study the role of feedback in instruction. There were 12 different treatments that each required several hours of instruction. I was fortunate that volunteer students from psychology were willing to persist long enough to complete these treatments. At the conclusion of the experiment, in an exit interview, one of the student participants made an unexpected request. “I really did well in learning this science and I would like to major in Xenograde Systems,” the name of the artificial science. I told her that she was the world expert in Xenograde Systems, that she had already learned all there was to learn about this artificial system, that the science of Xenograde Systems was imaginary, not real. A tear appeared in her eyes as she exclaimed “This is the first time in my life that I have really been able to excel in learning something complex. I really wanted to continue to learn more.” Her response provided me with a very important insight: real motivation comes from learning. When a learner is successful at learning a complex subject, and perceives that they are being successful, they are motivated to learn more.

Lesson 5. Perceived learning achievement is the source of real motivation.

Dr. Stolurow’s inspiration plus the opportunity to assemble a computer-based-instruction machine, develop instruction for this machine, and use this machine for research kindled in me a realization of the power of computer-based instruction not only as a way to present information but also as an effective laboratory instrument

¹ It should be noted that the computer-based-instruction system PLATO was also developed by the engineering department at the University

of Illinois during the same time period that we were developing SOCRATES.

for research on instruction. This early experience provided a firm foundation for my later work in developing authoring systems and attempting to automate instructional design.

The Professor Function

Dr. Stolurow wrote perhaps the first monograph on computer-based instruction titled simply, *Teaching by Machine* (1961). The ideas he described in this booklet and in his lectures to us concerning the possibilities of computer-based learning were way ahead of his time and many of these ideas were implemented only decades after he first suggested them. For me, his most influential lecture was to describe a two layered computer-based instructional system. The first layer is a teacher function that presents content to the student, accepts responses from the student, and provides feedback on these responses. Variations of this function characterize most computer-based and now Internet-based instruction. His most innovative function, however, was the professor function. If the student is having difficulty, the professor function evaluates the strategy being used by the teacher function and suggests a modification of the strategy or a new strategy believed to be more effective with this student. This adaptive instruction, at this sophisticated level, has only occasionally been implemented in the five decades since I first heard his lecture about the future of computer-based learning. I forgot much of what I heard and studied in graduate school but I always remembered the professor function and vowed that someday I would design a computer-based instruction system that implemented such a two level instruction approach.

Few Assumptions

My first year of graduate school was very difficult. Not only was there a tremendous amount of work, but there also seemed to be too many contradictions. The content of learning psychology challenged

many of my fundamental beliefs. There were numerous contending systems, each claiming to explain learning. I struggled for days trying to explain learning of the concept *green* using only S-R (stimulus-response) bonds. I found myself in the basement of the psychology building feeding rats that were on a deprivation schedule. Why was I feeding rats when I wanted to know how to teach children? I was about ready to give up and look for a real job.

About this time, B. F. Skinner visited the campus. Like my fellow classmates, I went to hear the great man. I don't remember any details of his lecture, but his response in the question-and-answer period changed my life. A member of the audience said, "Dr. Skinner, in your book (which he named) you said such and such (some detail of Skinner's theory); but tonight you seemed to contradict yourself by saying such and such"—he quoted a part of Skinner's speech.

"Hell," said Skinner, "do you think I believe everything I ever wrote?"

This was a great insight for me. Here was a great author saying he changed his mind and now disagrees with his earlier self. However, what he said next changed my life.

"What I've tried to do," continued Skinner, "is to make only a few assumptions and then see how much of human learning we can explain with only these assumptions." He went on to defend his theory and the point he made in his speech. I stopped listening before he ended his explanation.

Good grief, I thought, psychology is just an oar and a rubber boot as well. Psychological systems are not reality either, but merely logical systems that try to explain what we observe in the real world. Behaviorism is merely one logical system that is tested against reality to see how good a match can be found. Just like there can be many different number systems, there can be many different psychological systems.

Each is tested against reality to see how closely it fits, but none are reality, merely inventions.

Reinforcement for Lesson 4 – theories are merely attempts to find meaning in the real world but are, of themselves, not the real world.

I returned to my studies with renewed enthusiasm. I looked upon all theories as artificial systems and found them fascinating. I stopped trying to make all theories agree and force them to form one great truth. It became a game to see if I could identify the theorist's assumptions and conclusions. It was fascinating to observe that some systems were carefully constructed and logical, while other systems were very loosely constructed and often violated the canons of logic. I realized that theory building is our puny attempt to understand our world by inventing artificial systems and trying them out against the world.

Later in my graduate career I had one additional insight. We were studying learning and some instructional theories. It was apparent that learning theories tended to explain how persons acquire and store knowledge, but they have very little to say about how an instructor should structure and sequence knowledge to promote efficient and effective learning. It occurred to me one could build a logical system, a theory, about instruction.

There are Different Kinds of Learning

The class was the psychology of learning; the year was 1963. The 1960's represented the last decade where a behavioral, stimulus-response approach to explaining learning was prominent. Cognitive psychology was just beginning to make inroads into the thinking of experimental psychologists who were studying learning. Most theories were still trying to explain how learning takes place using a single paradigm. One member of my committee, Richard Anderson, came to the University of Illinois as a freshly minted

Skinnerian behaviorist who was just beginning his conversion to a more cognitive approach; another member of my committee, David Ausubel, was a cognitive theorist, and my chair, Larry Stolurow, was a pragmatist who was more interested in what worked rather than how it was explained by theory. My assignment was to write a paper about learning theory. I titled my paper "Two Kinds of Learning" and argued that learning *concepts* required a very different instructional approach than learning *facts*. I thought it was an insightful paper cutting across the theoretical divide that was becoming so evident in my studies. My professor liked my paper and handed me a manuscript that he was reviewing for publication. The manuscript was *The Conditions of Learning* by Robert M. Gagné which was published two years later (1965) by Holt, Rinehart and Winston.

Gagné examined the many different experimental approaches that studied learning and concluded that rather than different approaches to the same thing that there were actually different kinds of learning each of which required different conditions for learning to occur. In this first book he proposed eight kinds of learning which closely mirrored the different approaches to the study of learning. His position evolved over the next 20 years through four editions of his book. This book was perhaps the most important manuscript I read during my graduate education. Because of my own feeble attempt to propose such a hypothesis in my paper for my psychology of learning class I immediately resonated with Gagné's thesis. It seemed to me that indeed there were different kinds of learning and the instruction necessary to promote each of these different kinds of learning were indeed different. I determined to pursue this approach to instruction. I wrote a letter to Bob Gagné indicating that he had written the book that I wanted to write. This was the beginning of a long and simulating friendship and, while I never studied directly with Bob, his work has certainly been the

most influential for my own efforts. Even though I indicated to Bob that he wrote the book I intended to write, it took me 48 years after the first edition of *Conditions of Learning* to publish my book, *First Principles of Instruction* in 2013 (Merrill, 2013).

George Peabody College 1964-1966

Fifteen Minutes

It was difficult to contain my excitement as I entered my office on the campus George Peabody College, a small private university where I had accepted my first appointment as an assistant professor. The campus had been around for a long time. The building was old but well kept. My office was on the second floor in the corner of the building. I had a wonderful view of the quad of the campus, a large green space surrounded by classic buildings. Squirrels chattered noisily in the large maple tree just outside my window. How fortunate to obtain a faculty appointment that would allow me ample time to pursue research as well as teach. On the very first day I outlined a research study that extended the work done for my dissertation. The first draft of a research proposal lay on my desk at the end of the first day. I was very grateful for the proposal writing experience I had received in the Training Research Laboratory. Launching a research career was merely a continuation of my graduate education.

My department head was a very productive scholar who had obtained thousands of dollars in government research contracts. During the first few weeks of my employment he was always in his office hard at work whenever I arrived and was still hard at work when I left to go home for the day. He often responded to comments about his work habits with the statement, "Well, I was raised on a farm." He would merely nod when someone suggested that he must arrive with the birds. We all assumed that he must come to work at 4:30 or 5:00 A.M.



George Peabody College (pictured above) has since been incorporated into Vanderbilt University and no longer exists as an independent university.

After a few weeks I decided that it was time to launch a major academic activity and write a book. I had already learned that scholars publish. The manuscript was proceeding nicely. In those days we didn't have personal computers, and while I often composed my work on a typewriter I was not the most proficient typist in the world. After a chapter or two had been written it was submitted to our department secretary for her to type a draft that I could use to submit to the publisher.

"Could I speak with you a few minutes?" my department head requested a day or two later. "Writing books is private enterprise. It is not an appropriate activity for our department secretary to type a manuscript for you."

I was shocked. I thought books were part of the package. I expressed my surprise, but he was unyielding and suggested that I hire my own typist. Then, to make a touchy situation worse he said, "Writing a book should be done on your own time. I note that you aren't coming to work very early or staying late." Since my day was usually at least eight hours long it had not occurred to me that I was not working hard enough.

Anxious to make a good impression, I decided to come to work before my department head and stay until after he went home, even if I had to spend 20 hours at the office. The next morning, I arrived at 5:00 A.M. The building was dark. I had to find a

custodian to let me in the front door. No one was around. I went to work on my manuscript hoping that the hours from 5:00 to 8:00 A.M. would be perceived as my own time and that he would not feel I was shortchanging the university if I wrote my book during these hours.

At 7:45 A.M. he arrived at the office. He mumbled something about lots of stuff he had to do at home this morning making his arrival somewhat later than usual. When 5:00 P.M. came I continued to work. I was prepared to stay until after dark if necessary, determined not to leave until after my department head left. At 5:15 P.M. he locked his door and left. I continued to work until about 6:00 P.M. in case he was merely running an errand and would return. He did not.

The next day I arrived before dawn as the day before. Again my department head arrived 15 minutes before 8:00 A.M. Again he left at 5:15 P.M. I continued my early schedule for several more days until it was very clear that he never came before 7:45 A.M. and he always left between 5:15 and 5:30 P.M. So I adjusted my schedule to arrive at 7:30 A.M. and leave at 6:00 P.M. During the remainder of my employment at this institution my department head never came to work before I arrived and never left after I had departed. My department head commented on my diligence. I merely suggested that I was trying to follow his example. I never revealed my actual arrival or departure time.

Lesson 5. Fifteen minutes can make a very big difference. Most of my associates throughout my career have commented on my diligence and hard work. Amazing what 15 extra minutes can do.

Brigham Young University 1966-1967

In 1966 I left George Peabody College and accepted an appointment as an assistant professor at Brigham Young University. I heard about a professor at the University of Texas in Austin by the name

of Victor Bunderson who had acquired an IBM 1500 computer-assisted instruction system. A young colleague, Rex Arnett, and I jumped into his Volkswagen bug for the drive to Austin. Vic and I hit it off and shared our dreams for computers in education. We vowed that sometime in the near future that we would work together on computer-based instruction.

Stanford University 1967-1968

Multi-process

Three years after completing my Ph.D. I was invited to go to Stanford University as a visiting assistant professor. During the interview for this opportunity I was asked to make a formal presentation of some of my research. My paper was rather technical, involving some complex statistical analysis. One of the faculty members attending my seminar was Lee Cronbach, who had been one of my professors at the University of Illinois. I had great admiration for Dr. Cronbach and was flattered that he was in attendance at my presentation. However, during the entire presentation he was writing on a yellow pad. As far as I could discern he never looked up during my entire presentation. As I concluded my formal presentation and paused for questions, Dr. Cronbach, without looking up, asked, "On slide number 8 you were reporting your statistical analysis (which he then summarized). Did you consider (and he then raised some important concern about my assumptions)?"

I was dumbfounded. It appeared to me that he was not listening at all but then he asked a very detailed technical question about my analysis. Afterward I visited briefly with him and observed that he was writing during my presentation and consequently my surprise at his detailed technical question. He replied, "I have this very important proposal that has to be out tomorrow. I have to get it written this morning but I didn't want to miss your presentation." I was impressed by his ability to multi-process.

Lesson 6. I learned to multi-process; never go to a meeting without something else to think or write about.

At the end of the school year I was offered a job at Stanford as an assistant professor but my wife and I, after many long conversations, felt that we needed to return to Brigham Young University. The dean at Stanford, on hearing my decision, said: “Do realize that this is Stanford University and that we are offering you a position?” When I persisted in my decision he said with some emphasis: “You have just punted your career.” It didn’t help that my major professor called me and expressed the same concern. Vic Bunderson called me and suggested that if I insisted on leaving Stanford that I should come to Austin and work with him at the University of Texas. I did not accept his offer. Not all decisions are based on logic, and this was one of those decisions. I don’t know what would have happened to my career if I had stayed at Stanford or if I had gone to Texas but I do know that I have enjoyed a wonderful and productive career and have never had regrets about this decision.

Brigham Young University 1968-1979

Teaching Concepts

My exposure to Gagné’s *Conditions of Learning* instilled a determination to investigate instructional strategies that promoted different kinds of learning, I was working on an instructional strategy for teaching concepts. My studies of formal concept learning in graduate school suggested that learning a concept involved presenting examples and non-examples (Bruner, Goodnow, & Austin, 1956). Most of these laboratory studies had used formal concepts—red circles, green triangles, and so forth. Very little had been done to investigate teaching concepts using real-world tasks.

I had begun to prepare a proposal for doing research on concept teaching. A BYU student, Bob Tennyson, whom I had

not previously met, walked into my office and announced, “I’ve come to work with you.” I indicated that I had no research funds and would be unable to pay him for his work. He offered to work merely for the experience. “Have you ever written a proposal?” I asked. He had not, but was sure that he could. I handed him my notes, the call for a proposal from NSF, had a lengthy conversation about the idea, and sent him away. Two days later he put a draft proposal on my desk. It was terrible, but it was a draft. After considerable discussion and several drafts, we submitted the proposal. It funded Bob’s graduate education for the next three years.



Our first study (Tennyson, Wooley, & Merrill, 1972) found exceptional results. The best strategy for concept teaching consisted of presenting a definition, presenting matched examples and non-examples, presenting a divergent set of examples, and using an easy-to-hard sequence of examples. Our measure was correct classification of subsequent randomly sequenced examples and non-examples. We also measured classification

errors of overgeneralization, under-generalization, and misconception. We compared four treatment groups. We hypothesized that the group that did not have matched examples and non-examples would over-generalize—they did; the group that did not have a divergent set of examples would under-generalize—they did; and the group that had examples that shared an irrelevant attribute would form a misconception—they did.

We subsequently conducted additional studies refining our strategies using different age subjects and different concepts (Merrill & Tennyson, 1977a). Our research continued to support our winning strategy. Tennyson spent the next several years continuing the investigation of concept teaching (Tennyson & Cocchiarella, 1986; Tennyson & Park, 1980). We described and illustrated our instructional strategy in a book that has since guided the effective, efficient, and engaging design of concept lessons for many designers (Merrill & Tennyson, 1977b; Merrill, Tennyson, & Posey, 1992). It is still a very effective instructional strategy.

My intent was to follow a similar pattern to study other types of learning especially the learning of principles and problem solving. The plan was to conduct research to verify our hypothesized strategy and then publish a corresponding book: one for teaching principles, another for teaching problem-solving. But my pursuit of effective instructional strategies for different kinds of learning took a turn in another direction.

No Is Not the Right Answer!

I was invited into the office of the Associate Vice President. My tenure at the university was only a couple of years old and I couldn't imagine the reason for my visit. "Would you be willing to join the Learning Resources Division of the university and start a media research department?" was his surprising request. "I'll provide the money for two full time positions, a full time secretary and some initial operating capital."

I was stunned but recovered enough to replay, "I don't want to run a media research department. I'm interested in instructional research." And I stammered out the difference.

"Okay, then start an instructional research department."

This was an opportunity beyond my wildest imagination so I agreed to accept a half time appointment and launch this new research unit. For the next several years Darrell Monson, the Associate Vice President in the above scenario, proved to be the most valuable mentor I have had in my entire academic career. Thus was launched the BYU Department of Instructional Research and Development.

Shortly after we had launched this department, he suggested that there were some research funds available from the Mormon Church, who sponsored the university, and that we should write a proposal to obtain a portion of these funds. He proceeded to tutor me in the process of proposal writing. I worked very hard for three weeks researching, writing, and reviewing the proposal. We met every Thursday morning to review my progress. On the third meeting he indicated that he thought that we were ready and that he would take the proposal to the Academic Vice President for his approval. The next Thursday seemed weeks away as I awaited the results of my efforts and the receipt of my first major research funding since starting the new department.

On the following Thursday as I entered Mr. Monson's office I blurted out, "Did we get it?"

"No!" came the reply. "The vice president said no, he was unwilling to fund our proposal."

I was devastated. After all I had had excellent tutoring, the idea was sound, and in my naiveté I felt that the proposal was outstanding. How could it have been turned down? I turned to leave the office with my tail dragging between my legs.

"Where are you going? We have work to do."

“What do you mean? I thought that you said that he was not going to fund the proposal?” came my weak response.

“I merely indicated that he said ‘NO’, I didn’t say that we weren’t going to do the work.”

“I don’t understand”, I stammered. “Where are we going to get the money?”

“From the church! You and I both know that *NO IS NOT THE RIGHT ANSWER!*”

No is not the right answer. *No* is not the right answer. The concept was confusing to me.

“We have work to do.” he continued. “Sit down and let’s talk about how we are going to revise the proposal.”

So, for the next several weeks I was back to rewriting, doing more homework, finding additional data, rewriting, rewriting, and rewriting some more. Finally, after a much greater effort than went into the original proposal it was decided that we should take it back to the vice president a second time. I was much more skeptical this round. I didn’t anticipate a positive response. After all he turned it down once, why would he approve this revised proposal. I approached the office the morning after the presentation to the vice president much more subdued than during my previous visit. After saying good morning and chatting for a minute I finally got brave enough to ask how the meeting went.

“Oh! He was thrilled with our proposal. He said that this was more like it. That this was a much better idea than our first proposal. He is going to fund it.”

“But ...?” I started to wonder since it was really the same proposal but my confused musing was interrupted.

Lesson 7. “Remember, when it is right, *NO* is not the right answer!”

Lesson 8. I also learned a valuable lesson about proposals. There are three critical conditions to getting funding. First, you must know who writes the check, who approves the funding? Second, you must figure out

what is the passion of this check-writer; what does s/he want to accomplish? Third, you must present your proposal, not in terms of what you want to do, but rather in terms of what the check-writer wants to accomplish.

The Department of Instructional Psychology

When Darrell Monson hired me to form a Department of Instructional Research and Development I approached him about creating a department based on synergy. I suggested we hire professionals for the two positions he had authorized who had credentials qualifying them both to teach in the university as well as do research in our research department. He thought that was a wonderful idea. My dean was less than enthusiastic. He indicated there were no teaching positions available in the College of Education. Approving new classes would take several years to clear the curriculum committees of the university. Furthermore, at that time instructional research was not a recognized academic area. He was convinced we would be unable to place our students even if we could get a curriculum approved and find students who were interested.

In years past a number of courses in educational research had already been approved in the College of Education. At the present time these classes were not being taught, no students were currently enrolled in these courses, and no faculty were assigned to teach these classes. My previous experience working with a curriculum committee had taught me it was nearly impossible to get new classes approved because committees feared course proliferation. On the other hand, getting the name or description of an existing class changed was much easier.

One of the first professor-researchers that we hired for the new instructional research department was Harvey Black. During the recruitment process we discussed the idea of a new

department of instructional research and Harvey was as enthusiastic about the idea as I was. Because he was hired to work in the new research department, Darrell Monson interviewed him and an interview with the dean was unnecessary. Together, over the next few months, Harvey and I took the educational research courses that existed in the curriculum and proposed changes in titles and descriptions. We took the requirements for the educational research program and modified them to meet our needs. We also identified courses in psychology, computer science and statistics that would serve students we wanted to train in instructional design and development. We recruited another professor-researcher for our instructional research department and he joined our efforts at curriculum revision.

After many meetings with Monson and some of our associates at other institutions we felt that our modifications were ready to go to the curriculum committee. The first barrier was to get the Dean's signature. Our research department was not an academic department. If we were to offer degrees we had to be under an existing academic organization. We had many discussions about how to best present our proposal so that the Dean would not reject it. We already knew that he was not very favorable to our efforts.

Finally, we made our presentation. The Dean, as deans often do, appointed a committee of faculty members to evaluate our proposal. We met with the committee several times. We pointed out the advantage of a combined research and academic program. We argued there was no cost to the college since our salaries would be paid through the research department. We waited. We hoped. We prayed. We were very fearful that we would never get to the curriculum committee because we would be unable to get the signature of the Dean. We feared for a time the proposal had been buried in committee. However, after much cajoling on our part the committee finally made their recommendation to the Dean.

They recommended the program be tentatively approved and be reevaluated after a year. We forwarded our curriculum changes to the curriculum committee. Even though there was no resemblance among the original titles and descriptions and our revisions, since we proposed no new classes, no new program but only modifications in titles and descriptions, it was approved.

A member of the College of Education committee, in a private conversation with me sometime later, revealed that the committee had serious reservations about our proposal. First, our entrance requirements were so high they would eliminate many of the students currently in the existing graduate programs in the college. Second, there were no students in our program and they seriously doubted we would be able to recruit students. Third, they could not find another program resembling what we proposed so they doubted our graduates would be able to find jobs. Someone on the committee suggested they tentatively approve the program since it would never fly anyway and after a year it would go away for lack of students. This revelation of the committee's thought process was somewhat disconcerting but did not deter our efforts to make the program succeed.

The PhD program offered by our new Instructional Psychology Department was very unique. Our foundation classes were offered in different academic departments: learning in the psychology department; computer applications in the computer science department; statistics in the statistics department. We also decided that the bulk of our learning activities ought to reflect what these students would be doing in their jobs when they graduated. We were training students for either academic jobs or to work in large instructional development organizations in government and business. We felt that their job would entail several major activities: writing proposals, writing research or product reviews, developing instructional products, evaluating instructional products, and

conducting empirical investigations of instructional design principles. After only a few foundation classes the program consisted of a practicum in each of these areas. For each practicum the student would work with an individual professor. Each practicum had various amounts of academic credit from 3 – 12 hours. The idea was to persist until the product for that practicum was completed. Students were encouraged to submit their work for publication. When the practicums were completed the student then finished a dissertation, often merely an integration and extension of the work already accomplished.

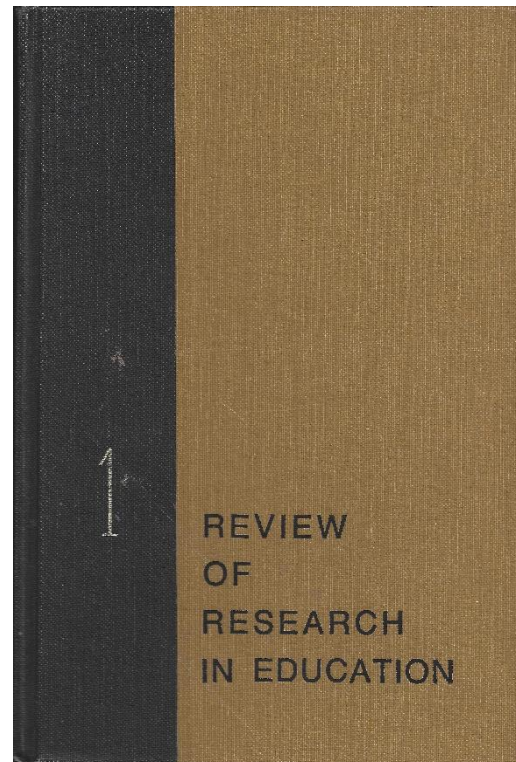
We were able to recruit students, but they differed from those already in the graduate programs of the college. Our students, because they were in a dual department one-part academic and one-part research, all were actively involved with our professor-researchers in real-world research projects. All of our students were able to publish research findings. When our first students graduated they soon became leaders who helped define the new field of instructional technology. Today, some of the outstanding leaders in this field are graduates of this program.

Reinforcement for Lesson 3, obstacles are often the doorway to greater opportunity, and Lesson 4, no is not the right answer.

Review of Research in Education

In 1972, it was a surprise and an honor to be invited to contribute a chapter, “Instructional Development: Methodology and Research,” for the first volume of *AERA Review of Research in Education* (Merrill & Boutwell, 1973). I invited one of my PhD students, Richard Boutwell, to work with me to prepare this chapter. As we examined the literature, it became evident that different investigators often used the same words in reference to completely different strategies. In order to make prescriptive statements about objectives (what to teach) and instructional activities (how to teach), it was

evident to us that there needed to be a descriptive language that allowed precise description of these two aspects of instructional design. A way to precisely describe what was taught and how it was taught was needed.



Remembering my encounter with Gagné’s *Conditions of Learning* while in graduate school, I remembered and resonated with Gagne’s categories of learning and his assumption that different kinds of learning required different kinds of strategy for effective presentation and assessment. Most of my previous explorations in learning theory attempted to explain all learning with a single set of principles. It was also difficult to translate these theories of learning into prescriptions for instruction.

I had previously attempted to clarify his categories by proposing a two-dimensional scheme (Merrill, 1971). As we attempted to describe the content involved in the studies we were reviewing, we felt that there were some categories missing in the Gagne scheme. It seemed more logical

for us to separate the content to be learned from the performance of the student with regard to the content. We suggested three levels of performance: *remember* content, *use* content, and *find* new content. Following Gagne's lead, we suggested four kinds of content: *facts*, *concepts*, *procedures*, and *principles*. The result of our reflection on how to describe what to teach was a performance-content matrix for classifying instructional outcomes in the cognitive domain.

Primary Presentation Forms

Remembering lesson 1, that a few simple elements can be combined into complex outcomes, it occurred to me that there must be a limited number of primary presentation forms from which all instructional strategies could be constructed and thus described. As we studied the instructional strategies in the literature we had collected, it occurred to us that there are two levels of content: a general level and a specific level. (Every composition teacher stresses this observation in their classes – but I didn't realize this until some years later.) We also observed that there were really only two things that an instructor could do with content: present it to the student or ask the student to remember or use the content. Combining these two dimensions led to the primary presentation form matrix (our three crayons). The content dimension had two values: *generality* (for the general case) and *instance* (for the specific case). On the instructional dimension we called presenting *expository* (*Tell*) and application *inquisitory* (*Do*). This led to four primary presentation forms: expository generality (EG), expository instance (Eeg), inquisitory generality (IG) and inquisitory instance (Ieg). We used the symbols in the parentheses as shorthand for describing instructional strategies.

TICCIT

When I left Stanford University in 1966, Vic Bunderson, whom I had visited during my first year at BYU, worked with the University of Texas to offer me a faculty

position. Much to his dismay I turned down the invitation and decided to return to BYU. I told him that I would invite him as a professor at BYU. He told me he would come only if he was given an appointment as full professor with a salary which at that time was considerably higher than most salaries then at BYU. In the early 1970s I finally was able to arrange an appointment for him at Brigham Young University. Just as the BYU Vice President offered Vic the job as full professor at the salary Vic had indicated, he received a phone call from NSF indicating that he had received major funding to build a new computer-based instruction system. He turned down the appointment at BYU because he felt he needed his lab at Texas to do the project. After all my work to arrange the appointment I was very disappointed.

Sometime later we shared a room at a convention, and he indicated that the NSF project was bigger than he anticipated. I told him that we had the resources at BYU that could help him with the project. We visited NSF together, and I returned to BYU with a contract to work on the TICCIT project.

The challenge of the project was to design a unique authoring system for a new dedicated computer system designed in cooperation with the *MITRE Corporation* specifically for computer-assisted-instruction. We struggled with many ideas for both the physical system and the authoring system. Bunderson proposed a system that had a variety of different instructional approaches built into the system. The learner could then select the instructional approach they felt was best for them. Harvey Black, my colleague at Brigham Young University and a collaborator on the *TICCIT* project, felt that students would not have sufficient information to make a wise selection before the fact. He suggested that a learner could only make a decision about what they needed next only when they were involved with the learning. We came up with the notion of a "momentary comprehension

index,” that is, what the learner understands at a given moment in time.

The new computer system involved in this project was very expensive, and because of this expense NSF decided to consolidate the project at only one university. After a site visit to BYU and much to the surprise of Bunderson and his team at UT, BYU was chosen for the site. Bunderson and many of his personnel from the Texas lab moved to Provo, Utah, to continue the project. In the meantime, we were struggling with how to author content for the system. I was working on Component Display Theory, and we had already identified primary presentation forms. Harvey Black suggested that only when given a rule could students determine if they needed an example. Only after having studied several examples could students determine if they were ready for practice. So we put the primary presentation forms as button commands on a special keyboard. Thus, given an objective for a segment of instruction, students could select *rule*, *example*, or *practice* by the touch of a button. We also added an *easy* and *hard* button, which allowed the student to get an easier or harder rule, example, or practice item. By means of these buttons, *TICCIT* was unique in that it allowed learner control, not just of content, but of the instructional strategy to be used.

During a site visit from NSF, someone raised the concern that students may not know which button to select next. The *help* key told them what was available but did not give them any advice about which presentation form would be most helpful. I remembered the lecture on the professor function by my major professor, Lawrence Stolurow. In this lecture, he suggested that the teaching machines of the future would contain a teacher function that would interact with the student and a professor function that would monitor the teacher's strategy, and when a given strategy did not seem to be working would provide advice as to what to try next. I answered

NSFs concern by suggesting that we would have an *advise* key that would access an advice function that would help the student decide which learner control key to select next.

After the meeting, our team strongly suggested that I had gotten carried away, that we had no idea how to build an advice system. After several members of our team had struggled with this problem, the task to design the system fell on my shoulders. Expert systems were not yet widely available, so I decided to build a decision tree that would provide the required advice to the student. To make this work, we determined an ideal strategy, “the all American strategy.” This strategy represented what we thought would be the best use of the learner control keys by a student. We then compared the student's path through the learner control keys with our ideal strategy. The adviser then gave “local” advice; that is, it recommended the key that would be the best for the student to try at the time the advice was requested. It was a very sophisticated early version of an overlay expert system.

Our team developed a complete basic algebra curriculum and an English writing program. The *TICCIT* system and curriculum were tested at Maricopa Community College in Phoenix and at BYU, and it continued to run at both locations until into the 1990s. At Maricopa Community College, *TICCIT* was used as main-line instruction. An evaluation of the system showed that English students scored higher on tests of writing skills and essay tests than did the comparison group in regular lecture classes. In the math classes students scored higher on their posttests than did the comparison groups in regular classes (Alderman, 1979). The English program was transported to a more current programming language and at the present time (2016) is still available online at BYU (<http://webclips.byu.edu>). I suspect that this program holds the record for the longest running CBI program.

There was an attempt to create a commercial version of the system. It was used for a time by the military. The advisor system was not included in the commercial version. To our knowledge, another system that allows learner control of strategy with an expert system advisor has not yet been built.

The *TICCIT* system pioneered a number of developments that are now common on all computer systems. Although multimedia was still in the future, the system was one of the first to have colored text and graphics that were pretty primitive by today's standards. The system used an early version of windows, also pretty limited by today's standards. The system constructed displays for the student "on-the-fly" from resource files that were combined with text templates to create either presentation or practice displays from the same content files. The design of the *TICCIT* system is described in Merrill, Schneider, and Fletcher (1980).

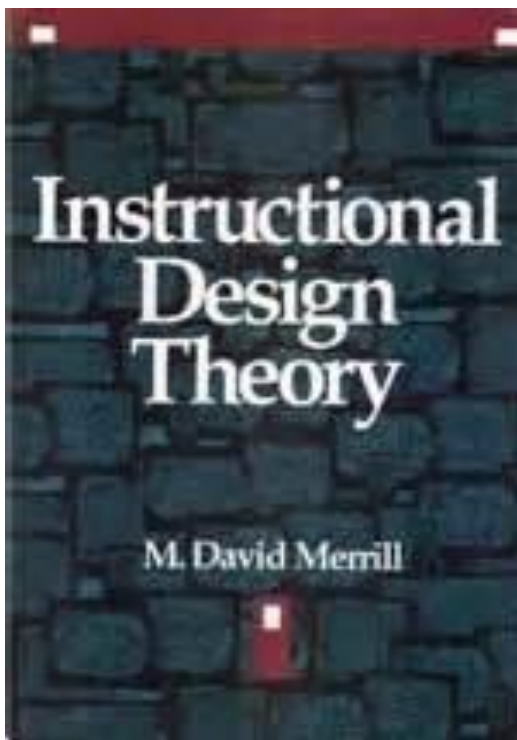
Learner Control

During my Training Research Laboratory experience in graduate school I determined that computer-based instruction was a significant vehicle for instructional research. As far as we were able to determine, no one had previously provided for learner control of instructional strategy. The *TICCIT* system allowed for both content control, selecting the next segment of instruction from a menu, and strategy control, provided by the *rule, example, practice, easy, hard, and advice* learner-control keys. We were anxious to learn more about the effectiveness of this version of learner control. With the *TICCIT* system, we had a very good laboratory instrument for conducting research. Because of our unique integration of the academic program with our research department our students conducted dozens of studies (Merrill, 1975, 1980, 1984) of learner control of instructional strategy.

Component Display Theory

Our new Instructional Psychology academic program in cooperation with our new Instructional Research and Development Department provided an opportunity for our students to conduct scores of research studies exploring many aspects of the task-content matrix and primary presentation forms. Remembering Skinner's comment, to make a few assumptions and then see how much you could explain about learning, I thought why not make a few assumptions about instruction and then see if we could prescribe more effective instructional strategies. Taking the results of our research with primary presentation forms and the task-content matrix for describing instructional content, I formalized our content classification scheme and strategy description into what came to be called Component Display Theory (CDT). The name deserves some explanation. We felt that each primary presentation form comprised a display to the student. These displays are the components of an instructional strategy, hence, component display theory.

CDT consists of three parts: (1) a scheme for describing the content to be taught—the task-content matrix; (2) a scheme for describing instructional strategies – primary presentation forms, secondary presentation forms, and interdisplay relationships; and (3) a set of rules that relate the two. The theory identifies which combination of primary presentation forms are most appropriate for teaching each cell in the task-content matrix. The presentation of CDT in the three Reigeluth books *Instructional Design Theories and Models* (Merrill, 1983, 1987a, 1988) provided the wide spread dissemination of this work. The most complete presentation of CDT is found in my book *Instructional Design Theory* (Merrill, 1994).



Elaboration Theory

One of the exciting activities as a faculty member in a graduate program is recruiting new graduate students. This influx of some of the smartest people in the world into our graduate program is the primary motivator to stay in academics and not accept any of the several offers I had throughout my career to move into the business world. The resume of one such student, Charlie Reigeluth, came across my desk. I was very impressed by his resume and made a point of meeting him the day he arrived and inviting him to work with me in our Instructional Research and Development department.

Perhaps my favorite teaching moments occur when students ask me an insightful but challenging question about instructional design. Often, but not always, the question triggers some idea that I may have been thinking about. When this occurs I have been known to explore the idea out loud in front of my graduate students. One such occasion occurred when a student asked me about knowledge structure as it related to instruction. Our task-content categories, based on an extension of Gagné,

represented different strategies for different kinds of outcomes but did not tie these individual strategies into some form of coherent whole. Gagné had proposed learning hierarchies that were based on prerequisites as learning progressed but this seemed like a limited approach. My lecture suggested starting with a simple version of a whole task and then teaching successive layers of elaboration by gradually increasing the complexity of the task.

Charlie Reigeluth, who was a student in this particular class, approached me after the lecture and asked, “Have you published this idea you presented today?”

I indicated that while I had given the idea some thought that this extemporaneous lecture was the first time I had tried to present the idea in an organized fashion, so no, I had not yet published this idea.

“May I write your lecture for possible publication?” was his request.

Of course I agreed and a few days later he presented me with an article describing what he called *Elaboration Theory* as a way of organizing content. Not only did he capture the ideas I had presented in my lecture but he elaborated these ideas in a very insightful way. We published a version of this paper (Reigeluth, Merrill, Wilson & Spiller, 1980) and following his graduation with his PhD Charlie pursued this idea in his research and a series of articles over the next several years with some of his students. (Reigeluth & Stein, 1983; Reigeluth, 1999a) Elaboration theory started our thinking about whole tasks that led to the principle of task-centered instruction in our more recent work.

Courseware Inc.

Gerald Faust, a University of Illinois student colleague and PhD graduate from the Training Research Laboratory, joined the *TICCIT* project in the BYU Instructional Technology Research and Development unit along with Vic Bunderson and his personnel from the University of Texas CAI laboratory. Dr.

Faust was drafted into the military as he finished his PhD and had formed a close relationship with three other trainers during his service. He suggested that Vic Bunderson and I join with him and his associates to form an instructional development company with the purpose of developing training materials for military clients and others. With the help of Darrell Monson, *Courseware Inc.* was the result. My role was a vice president directing the research division of the *Courseware Inc.* which correlated well with my role as chairman of the new Instructional Psychology academic department and Director of the Instructional Research and Development Department at BYU.

Courseware was very successful in developing a considerable body of training materials especially for the Navy. The headquarters of the company moved to San Diego to be near our primary client. I remained at BYU coordinating the research division of the company since most of the research was being conducted in cooperation with our students at BYU. CDT formed the core of ideas that informed the instructional development work of this company.

Creative individuals, especially when they push the envelope of tradition, often need a protector. Darrell Monson, as a university vice president, was the protector for both the Department of Instructional Psychology and the Instructional Design and Development research group. He was diagnosed with terminal cancer in 1975 and passed from this world in December of that year. With his passing the media division of the university, which also served a primary developer of audio visual materials for the LDS Church, was divided among several other entities in the university. Our department was in the College of Education but the Instructional Research and Development Department was not. With the reorganization resulting from Monson's passing both organizations were moved under the dean of the College of Education. BYU is a hierarchical organization where

deans have the authority to appoint department chairs and directors. This particular dean was never very favorable toward either of these organizations and shortly after the reorganization I found myself "released" from my responsibilities as the Instructional Psychology Department chair and as director of the Instructional Research and Development Department.

I requested and was granted a sabbatical leave and spent the year working full time with *Courseware Inc.* When my leave was over I returned to the university where I was now merely a faculty member in the department I had helped form and no longer director of the research division. Prior to this moment in my career I had spent a significant amount of time and energy planning and directing both the academic program of the department and research division. Being forcefully relieved as chair of our academic department and director of IRD was a very difficult emotional period in my life. I made an important career decision that for the remainder of my career I would concentrate my energy on my own research and not accept administrative responsibilities. I submitted and received a significant research contract, taught my classes, and largely withdrew from the two organizations I had helped form.

At the end of the first year back at BYU I had pretty well smoothed over the hard feelings resulting from the reorganization and had settled into my new role as scholar, researcher, and teacher. After careful consideration my wife and I decided that my career at BYU was over and it was time to move on. We moved to San Diego to work full time with *Courseware Inc.*

As a result of being closer to the everyday operation of the company and having closer access to the financial situation of the company it became apparent that the company was on the verge of bankruptcy. It seemed inevitable that unless some of the key people stepped aside that

the company would not be able to survive². In a conversation at a convention, Richard Clark, who was a faculty member at the University of Southern California, suggested that I should consider joining USC as a faculty member. As I learned of the precarious condition of *Courseware*, I called Richard and indicated that I would like to join the USC faculty. “I’ll begin to work on getting you an appointment and see if we can’t arrange it by next year.”

“But!” I exclaimed “I need an appointment now, this fall.”

“USC is a major university; it is not possible to arrange a new appointment that quickly.”

“Look around the college and see if someone isn’t sitting on an approved position that they haven’t been able to fill” I suggested only somewhat seriously. “I have a very strong resume (partially because of our research efforts in the Instructional Research and Development Department) and I may be able to fulfill such a position.”

To my surprise Dick called me back a few days later and indicated that indeed there was a position in the Curriculum and Instruction Department that they had been unable to fill. He indicated that the dean was very frustrated with their inability to fill the position. When the dean looked at my resume he indicated that he would strongly encourage the C&I department to consider hiring me. The dean was my strong advocate and I was reluctantly offered a position by this department. In the fall of 1979, only three months after moving to California, I resigned my position at *Courseware Inc.* and joined the faculty at USC. During my second year at USC there was an opening in the Instructional Technology Department

and I moved there. I was back to being a scholar, researcher, and teacher at a major university.



University of Southern California 1979 – 1987

Microteacher Inc.

The Apple II computer came on the scene in late 1977. One of my students Bennie Lowery, had started a company to train young people in computer literacy using the Apple II. Benny took my class in computer-based instruction where it was suggested in one of my extemporaneous lectures that the Apple II might be the perfect vehicle for developing courseware for use by students in the home. Bennie told me of his company and together we decided to undertake the development of CAI for the home. *MicroTeacher Inc.* was born. Our first project was a beginning reading program, originally developed by one of my students, Norman Owens, for a class project. One of the great features of the Apple II was its extensibility. A card could be easily added to the machine to enable it to have additional capabilities. One of these was a sound card that would deliver digitized speech via the computer’s speakers. Digitizing speech for the words and letters

² The company survived for several more years but eventually was disbanded.

in our program was available only on a very expensive digitizer and we ended up paying \$50 per word to obtain the speech we needed for our program. (Big contrast with the easily availability of speech recognition available today -- 2016). Needless to say we kept the number of digitized words to a minimum. Nevertheless, we had sufficient speech to introduce 4- and 5-year-old students to the letters of the alphabet and some key words. The program was very successful. In one study (Gallup, Lowery & Merrill, 1986; Shore, Lowery, & Merrill, 1986) Hispanic children were brought to a 2nd or 3rd grade reading level after an hour a day for 6 weeks in the program. The program enjoyed a short lived commercial success.

We also developed programs in early arithmetic, writing skills, and a program teaching meter in poetry. The Apple II had very limited memory (128K) so including much content was a challenge. This machine also used floppy disks that were also very limited in size. Based on our work on the *TICCIT* system I suggested that education programs could be designed just like other applications, such as word processors and spread sheet programs, which separated the strategy from the content to be presented or manipulated. The idea was to write an instructional algorithm, a piece of program that could present and request responses from the student for a particular instructional strategy. This algorithm had place holders for the content to be taught. The instructional algorithm was loaded into the memory of the computer and the content to be taught was contained on the floppy disk. Each piece of content was then loaded in turn and when the student had finished interacting with one piece of content it was discarded and the next piece of content loaded into the instructional algorithm.

³ After graduation and a couple of years as a faculty member at Utah State University, Zhongmin immigrated to the United States, changed his name to James Z. Li, started and

The products developed by *MicroTeacher Inc.* were originally marketed with some success by *EduWare*, an educational software company. At one point this company was acquired by a large software company who specialized in applications for business. Shortly after the acquisition they made a decision to stop selling educational products and our work sat on a shelf without further sales. After some difficult negotiations we finally obtained the rights to our products and undertook our own marketing efforts. We were very successful as a development company with another company marketing our product, but when we attempted to also be a marketing company we learned that professors, without sufficient business training or experience, are woefully underprepared to run a company. We also learned the importance of adequate capitalization and our efforts eventually failed and our products remained unavailable.

Instructional Design Expert System

In my class on authoring systems for computer-based instruction I asked the students to write a paper suggesting their ideas for the development of an authoring system for computer-based instruction. Most of the papers reflected back the ideas I had discussed in class based largely on our experience on the *TICCIT* project. One paper stood out. I could barely read the paper because of the extremely inadequate use of the English language, obviously written by a foreign student, but the ideas suggested were imaginative and considerably extended my own thoughts for such systems. The next class period I asked Zhongmin Li³, the author of the paper, to meet with me after class. He was very nervous and immediately apologized for his inadequate ability to write in English. I told him I didn't care about his grammar or

ran a very successful business, and then went on to coach young mathematics students. His students often won math competitions across the country.

misspelled words or even his unusual sentence structure, my interest was in the very ingenious ideas he expressed in his paper. Zhongmin had extensive experience in computer science and had learned to program mostly on his own. He was simultaneously pursuing a master's degree in computer science while pursuing his PhD in instructional design. He was relieved and surprised when I offered him the opportunity to work with me. I had some limited funds from a research project that I offered to him.

During this period one of my consulting opportunities was to review some computer-based instruction developed by a major Air Force training company. The instruction was early CBT and involved a kluge of equipment including two monitors and an analog audio system. The instruction consisted of wall-to-wall text on one monitor and a very nice graphic on the other monitor. The audio read the text to the student. I suggested that this was not a very effective instructional strategy, and Mayer (2001) has since demonstrated the ineffectiveness of this instructional approach. The company agreed to let us try to build some instructional shells that would enable their designers-by-assignment to build more effective instruction for different kinds of learning outcomes. I approached Zhongmin about building such a shell for naming parts. He agreed. A week later he demonstrated for me not only a shell into which any content for naming the parts of something could be imported, but he also demonstrated an authoring system that could be used by designers-by-assignment for importing the content into the shell. Subsequently, we also designed and programmed shells for teaching concepts and teaching procedures (Li & Merrill, 1990).

We proposed and received funding from the Army to design and build an instructional design expert system. We had already demonstrated with the *TICCIT* project that we could develop programs

with built-in instructional strategies that required authors merely to provide content in an appropriate format and then the system could teach this content. Zhongmin and I thought that perhaps we could develop an expert system that would implement Component Display Theory and be able to prescribe appropriate instructional strategies. Expert systems were just coming on the scene and we were able to use this technology to develop a program that would ask the author a few key questions and then prescribe an appropriate instructional strategy for teaching their content. (Merrill & Li, 1989). It then occurred to us to combine our authoring shells with the prescriptive system so that the system would not only recommend an appropriate strategy but would also select an appropriate authoring shell and prompt the user to import their content into this shell for delivery to their students.

I have had some very bright students, but Zhongmin is at the top of this list. Over the next few years, as we worked together, he demonstrated again and again not only his extremely efficient and capable programming ability but even more importantly his insight and imagination as he always leap-frogged my ideas to the next level.

* * * * *

“How long does it take you to get to work?” was a frequent question when I found myself living in San Diego area and working in Los Angeles at USC. My answer was usually, “Two to five” hours depending on time of day and traffic. I solved this problem by taking the train to Los Angeles from Del Mar and staying a few nights in town to avoid the long commute each day. Such an arrangement is very hard on a family and I suggested to my wife that perhaps we should consider another move to a university not located in such a major metropolitan area. She wisely counseled “Don't resign until you have another job firmly in hand.”

Nick Eastmond called me and indicated that Utah State University would like to interview me for a possible position. Having just returned from a site visit to their campus I indicated that I was not interested especially because their salaries were considerably less than I was making at USC. After some persuasion I finally agreed to visit the campus and give a lecture to their students but assured him that I was not interested in a position.

The lecture was well received. They had gathered 25 or 30 outstanding PhD and Master's students who had all been prepped by reading my recent papers and armed with questions about my work. I was very impressed with the quality of the questions and how informed these students were about the field. (Interestingly I never saw this many graduate students gathered again at USC.) Following the lecture, I agreed to interviews with faculty and administrators at the university and after a couple of days felt that USU might be a great place to work. However, the salary was too low for the needs of my family. We negotiated that for a while and I finally accepted the appointment and remained at USU for the next 17 years. .

Utah State University 1987-2004

I had been successful in acquiring a number of research contracts for our work on designing instructional algorithms and also for our work on designing an instructional design expert system. Since these contracts were with me personally, rather than with USC, I was able to take them with me to Utah State. In fact, I learned after my arrival, that the arrangement Don Smellie had worked out with the administration in order to get the salary I requested was to indicate to them that I would be able to cover at least half of my salary with research contracts, which fortunately was the case for most of the remainder of my career at USU.

Zhongmin Li was being funded by these contracts and was finishing his PhD simultaneously with my move to Logan. I suggested, and he agreed, that he join me at

Utah State as a research professor and part of the research group I formed at USU. At USU I determined that there was an advantage to running my research contracts through the research division of the university. This enabled me to pay part of my salary and the salary for two full time research professors, Zhongmin Li and Mark Jones, another bright programmer, and several graduate students in the USU Instructional Technology PhD program.

Automating Instructional Design – Instructional Transaction Theory

Our research projects funded by several governmental agencies all focused on developing tools for automating instructional design. In order to develop our tools for automating instructional design, we found that it was necessary to develop a more precise instructional design theory (Merrill, Li, & Jones, 1990a, 1990b, 1991). We described subject matter content as knowledge objects so instructional algorithms could use this content in different kinds of instructional strategies. It was also necessary to develop a more detailed description of instructional strategies on which our instructional design shells could be based. We called our work second generation instructional design. (See Li & Merrill, 1990; Merrill & ID2_Research_Team, 1993; Merrill, Jones, & Li, 1992; Merrill, Li, & Jones, 1991, 1992a, 1992b)

Automating Instructional Design – ID Expert

At this time a company from Germany, *Boden Software*, visited our campus and subsequently provided a very large contract to build ID Expert, a commercial version of our instructional design expert system (Li & Merrill, 1991; Merrill, 1987b; Merrill & Group, 1998; Merrill & Li, 1989, 1990). ID Expert was a very ambitious project. The goal was to reduce the labor involved in authoring computer-based instruction by an order of magnitude.

The system consisted of several subsystems working together: 1) a set of reusable instructional strategy algorithms for different kinds of instructional outcomes based on Component Display Theory; 2) a decoupled knowledge base that allowed the designer or system to attach a given knowledge object to any of the instructional strategy algorithms, thus allowing for reuse of knowledge objects within the system; and 3) a set of instructional parameters that allowed the instructional strategies to be modified by merely selecting a different parameter value (Merrill, Jones, & Li, 1992; Merrill, Li, & Jones, 1992a). The ultimate goal was to include a “professor” function that would monitor student performance and automatically adjust strategy parameters as necessary to accommodate the learning needs of a given student. This adaptive instruction feature was planned for phase 3 of the project but was never completed because of the demise of the funding company.

Version 1 of the system was completed when the company suffered serious financial problems and discontinued its business. We also lost another very large contract at this same time and the work on ID Expert was discontinued.

Automating Instructional Design – Electronic Textbook and Instructional Simulator

Mark Lacy and Leston Drake joined our Research Group shortly before the demise of the ID Expert project. Using largely internal funds, we were able to continue our work to develop systems for automating instructional design. Mark was the primary developer of the *Electronic Textbook*, a very easy-to-use authoring shell with built-in instructional design for teaching naming, concepts, and procedures (Merrill & Thompson, 1999). Leston Drake was the primary developer of the *Instructional Simulator*, a very easy-to-use simulation authoring and delivery system that

combined instructional strategies with simulation (Merrill, 1999).

These products enjoyed a brief commercial success through our company *River Park Instructional Technologies* but this company was dissolved and the distribution of these products ceased when Lacy and Drake graduated from USU to form their own instructional development company *Letter Press Software*.

First Principles of Instruction

The primary purpose of Component Display Theory was to find a more precise terminology for describing instructional outcomes and strategies. The second purpose was to identify relationships between the outcomes of instruction and the strategies thought appropriate to produce these outcomes. Our intent was to identify underlying principles that were common to all models of instructional design. In spite of my intentions, Component Display Theory was often characterized as an alternative approach to instructional design rather than a more precise way to characterize existing approaches to instructional design.

In the preface of *Instructional Design Theories and Models Volume II* (Reigeluth, 1999b) Charlie indicated that there were many different instructional design theories and models, and that designers should learn many of these different approaches and use the approach that was most appropriate for a given situation. I thought that most of these different approaches were all based on the same underlying principles and that they differed mostly in implementation details. I set out to determine the fundamental principles that were common to many of these different approaches. The result of this effort was a set of principles that I called “First Principles of Instruction.”

The five principles are the activation principle, the demonstration principle, the application principle, and the integration principle all in the context of a problem-centered instructional approach. Over the

next few years I tried to elaborate, clarify, and explain these principles and to demonstrate their presence in other instructional design theories and models (Merrill, 2001a, 2002a, 2006a, 2006b, 2007, 2008, 2009). I also proposed a content-first alternative to the classic Analysis, Design, Development, Implementation, Evaluation (ADDIE) instructional design model called A Pebble-in-the-Pond approach to instructional development (Mendenhall et al., 2006; Merrill, 2002c, 2007).

In 2004 I had the opportunity to serve as an education missionary for the Church of Jesus Christ of Latter-Day Saints. My assignment was to work with the faculty at the Church's Brigham Young University-Hawaii campus. I requested a leave of absence from USU in order to fulfill this assignment but my dean would not approve a leave for this purpose. Unable to convince him after considerable negotiation I decided to formally retire from USU in order to serve this mission.

Our most successful project during the first stay at BYU Hawaii was the development of a problem-centered Entrepreneur Course delivered online (Mendenhall, et. al. 2006). Anne Mendenhall, a graduate of the program at USU, was the lead developer of this very successful program. Several other courses on campus also implemented the problem-centered approach of First Principles of Instruction in their courses and several found their way onto the Internet.

Following this experience, I was offered a visiting professor position at Florida State University during the winter semester for the next three years. I was in residence at FSU during the winter semester of 2007. On my return to Utah I was invited to serve a second mission at BYU Hawaii to continue our work with the faculty under the then new president of the university. We returned to BYU Hawaii during all of 2008 but my two-year assignment was cut short by some health problems. I arranged to teach my courses at FSU during the winter

semester online from Hawaii during 2009 and again in 2010 after my return to Utah.

During this second assignment to Hawaii my wife and I had the opportunity to visit Japan and Korea for a lecture to several different universities. My topic was First Principles of Instruction and our experiences with implementing this approach at BYU Hawaii and in other venues. At the conclusion of several of these lectures students or faculty in attendance would ask where they could get more information about First Principles of Instruction. I would tell them that I was writing a book on the subject. During one of these exchanges the faculty member sitting next to my wife in the back of the room whispered to her "Please get Dr. Merrill to write this book, he keeps telling us that he is writing it and we are anxious to get it."

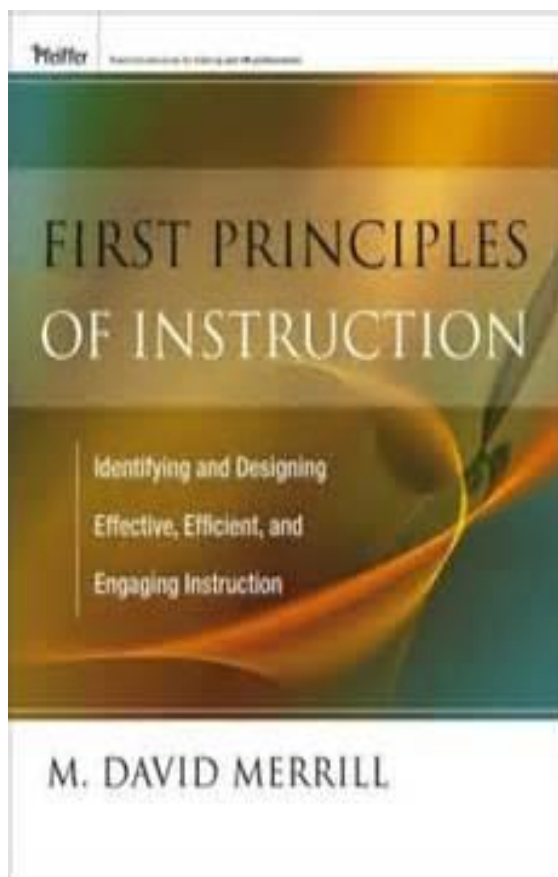
After we returned to our new home in St. George I was able to continue to teach courses online at FSU. I had also established a relationship with the University of Hawaii during my stay in Hawaii and was invited to teach an online course for UH, which I have continued to do about once each year since. I also reestablished my relationship with the department at Utah State University and have taught one or more online courses each year at USU. One day as I was working on one of these courses my wife walked into my office with that look that wives sometimes get. "Are you really writing a book about First Principles?" she asked.

"Yes, I've thought a lot about it, I've written a number of articles that I can use in such a book."

"When?" was her piercing question "I don't see you actually writing such a book. You are not getting any younger."

Her prodding awakened me to the reality that if I didn't get started the book would never appear. On a consulting trip shortly thereafter I found myself snowed in, unable to fly out for three days. I pulled out my notebook and decided this was the time to seriously undertake writing my book. By the time I returned home I had a rough

draft of the outline. Encouraged, I submitted it for consideration by several publishers including Pfeifer. No response. I called my good friend and colleague Ruth Clark, who had published several books with Pfeifer seeking her referral to an appropriate editor. She indicated she would call her editor Matt Davis. The next morning Matt called me indicating that Pfeiffer was interested in publishing the book. For the next two years I had one of the most rewarding experiences of my career preparing this book for publication. The result was the 2013 publication of *First Principles of Instruction: Identifying and Designing Effective, Efficient, and Engaging Instruction*. Fortunately, those professors who encouraged my wife to motivate me also followed up by translating the book into Korean in 2014. I also visited China on several occasions and my colleagues in China translated the book into Chinese in 2016.



I continue to write and teach courses online after my formal retirement. My current assignment is working with the faculty at the American University of Nigeria. I was invited to help them encourage their faculty to use *First Principles of Instruction* and a problem-centered approach as their preferred method of teaching. We have conducted workshops and online conferences, but the most successful approach came when I was asked to review the course syllabi and canvas implementation for each faculty member to see the extent to which their course uses a problem-centered approach. In the second round of reviews, we are seeing dramatic changes in the approach used by some of these faculty.

Summary

The most rewarding experiences during these many years have been my interaction with very bright students. Most of the good ideas I've had come about as a result of interaction with, or questions from, my students. I have had the good fortune to coauthor papers with many of these individuals. Only a few have been mentioned in this paper associated with specific projects but the hundreds of others have kept me inspired, challenged, and engaged during my more than 50 years as an academic. If I had a wish it would be to do it all again, of course it would be nice to start over with what I have learned.

I hope that this nostalgic journey through a few highlights of my career has provided a bit of insight into how ideas develop and evolve. What have I learned about how to make instruction more effective, efficient, and engaging? Considerably more than I knew at the beginning of my career. I do believe that we know a bit more about how to design instruction that works. I have been gratified by the many designers who have found our work helpful; however, far too much instruction is still not effective, not efficient, and not engaging. Do we have more to

learn? I believe that we have just scratched the surface of how to design what to teach and how to teach.

What is my greatest concern? I'm concerned that there is not more effort being devoted to this question. The current zeitgeist seems to emphasize communities of learners, repositories of content, and electronic communication. There seems to

be an assumption that information is sufficient and that direct instruction is no longer necessary. The Internet is swollen with information, and amidst this flood, there are only isolated islands of effective, efficient and engaging instruction. My hope is that our work may continue to provide a catalyst for further efforts to find ways to improve instruction.

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About Acquired Wisdom

This collection began with an invitation to one of the editors, Sigmund Tobias, from Norman Shapiro a former colleague at the City College of New York (CCNY). Shapiro invited retired CCNY faculty members to prepare manuscripts describing what they learned during their college careers that could be of value to new appointees and former colleagues. It seemed to us that a project describing the experiences of internationally known and distinguished researchers in Educational Psychology and Educational Research would be of benefit to many colleagues, especially younger ones entering those disciplines. We decided to include senior scholars in the fields of adult learning and training because, although often neglected by educational researchers, their work is quite relevant to our fields and graduate students could find productive and gainful positions in that area.

Junior faculty and grad students in Educational Psychology, Educational Research, and related disciplines, could learn much from the experiences of senior researchers. Doctoral students are exposed to courses or seminars about history of the discipline as well as the field's overarching purposes and its important contributors. .

A second audience for this project include the practitioners and researchers in disciplines represented by the chapter authors. This audience could learn from the experiences of eminent researchers—how their experiences shaped their work, and what they see as their major contributions—and readers might relate their own work to that of the scholars. Invitations to potential authors were accompanied by Tobias' chapter in this series for illustrative purposes. Authors were advised that they were free to organize their chapters as they saw fit, provided that their manuscripts contained these elements: 1) their perceived major contributions to the discipline, 2) major lessons learned during their careers, 3) their opinions about the personal and 4) situational factors (institutions and other affiliations, colleagues, advisors, and advisees) that stimulated their significant work.

We hope that the contributions of distinguished researchers receive the wide readership they deserve and serves as a resource to the future practitioners and researchers in these fields.



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