Wired for Change:

Mandated Technology as an Opportunity for Change through Constructionism

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ABSTRACT

Various states, supported by the Congress and the President, are mandating the use of computer related technologies, with special emphasis on the Internet. The teachers who are expected to implement this use are not just unprepared in the sense of technical training, they are unprepared in the sense of a fundamental perception. Central to the current vision of curriculum and instruction is the cognitive illusion that all things are measurable. Rising from this illusion, a secondary almost mystical, belief holds that the school can be viewed in the same way that businesses view themselves and can be held to the same standard of efficiency. The combined view holds that knowledge is made from an inventory of discrete bits that can be poured into identical assembly line students.

The purpose of this paper is to contribute to the process reconciling the consequence of the mandate (forced school reform without a clear understanding of its nature) and the conflict within the school culture rising from the lack of a shared vision that can give meaning to the technology. To do this, I explore an understanding of curriculum and instruction built on the cognitive science philosophy called *constructionism.*

The backbone of this understanding is based on concepts of how humans learn that are culled, not just from the body of education related literature, but from a variety of disciplines: linguistics, philosophy, history, neurobiology, psychology, sociology, and mathematics. Those ideas that are more recent are mixed with concepts from the past that are nearly forgotten (Froebel), are under-appreciated (Piaget), or have been rediscovered (Vygotsky).

It is the thesis of this paper that school culture *will* change through mandated technology. This change opens an opportunity for a response that alters the vision of learning without destroying the institution.

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ACKNOWLEDGMENTS

John Donne tells us that "no man is an island." Donne's words are appropriately humbling to a writer who believes that he alone created his work; others always contribute support. In the pain of generation (reading, assimilating, collating, and writing), it is easy to overlook or merely accept their help as something that is due. On reflection, the realization comes that the end product might not have existed at all without the *others*: those who triggered inspiration, and those who made smooth the irritations that can subvert direction or purpose.

Of those who filled both functions, appreciation must be allotted in a major portion to my committee. My gratitude cannot be expressed through a pro forma "thank you." It is sincerely and deeply felt. Their efforts are a reflection of their distinction as professionals.

Susan Fisher maintained the thankless job of keeping me on schedule and focused with a combination of stolid firmness and compassion. Marianne Dove assumed the role of Socratic critic, challenging the ambiguity that is the consequence of constructing an untested vision. Robert Levin walked with me in the brainstorming sessions that I needed to overcome the mental blocks that occur when there are so many directions that can be taken. If I have failed to communicate through this paper, it is not their fault.

Jean Romeo, reference librarian in Maag Library, was especially helpful in the early phases of gathering materials. She went the extra miles that are so helpful to the novice researcher. She maintained her professionalism no matter how brashly I imposed requests rising from questions of date or authenticity.

Because of the bureaucratic policies of NEOMIN, I do not have an account giving me access to the internet at Liberty High School. Without the generosity of Alice Crosetto, my colleague in the school's Information Center, this paper would not reflect any timeliness of thinking from a variety of areas. By sharing her account and password, I was able to tease out sources that expanded my perceptions of constructionism, complex systems, and the internet itself—to mention but a few areas touched on in this paper.

I would not have discovered chaos and the Mandelbrot set, both of which eventually led me to the fringes of the science of complexity, without the stimulation of students from Max Shellenbarger's classes. Their enthusiasm and determination to solve self-imposed problems are living proof and confirmation of the tenets of constructionism.

Finally, I want to publicly thank my companion, Ida McLaughlin, for being the buffer that kept personal and social obligations from overwhelming the time needed to read, reflect, and write.

PREFACE

This paper is a product of a practicing classroom teacher. It is a product derived from the perspective of an all-too-typical full-time teacher doing part-time graduate work. It is about expectations, and the reconciliation of expectations to practice. It is about technology, and the mapping of technology onto curriculum and instruction.

Obviously, I cannot claim to be the average classroom teacher. If this were so, this paper would not exist. Honesty, however, demands that I confess to performing like the average teacher in the classroom. To do otherwise is to break with the culture. Seldom does anything momentous happen in my classroom, and when it does, my students initiate it without help from me. My students earned many awards in the name of Liberty High School (near Youngstown, Ohio); awards earned without any help from me.

The recent mandates for bringing technology into the classroom may be just the opportunity to break the constriction of the culture mold and explore change—*change*, not reform nor revolt. I want to examine the character or nature of possible change. But, I do so remembering Jose Ortega y Gasset's observation that "[i]n the disturbances caused by scarcity of food, the mob goes in search of bread, and the means it employs is generally to wreck the bakeries (1932/1964, p. 60)."

In spite of the explosion of such digital marvels as CDs, CD-ROM encyclopedias, the Internet, and the emerging interactive distance learning and virtual reality, most educators do not understand their own role in relationship to the technology coming into their schools or classrooms. This is not surprising since the institution as a whole does not understand, much less address, any of the external changes that are driven by technology, nor does it understand the internal ramifications of those changes. New perspectives will be necessary to displace current understandings of the educative process and its execution.

The vision of most educators is limited by their experiences which, through no fault of their own, are constricted to a blind reliance on traditional practice, machine-cum-science views of efficiency, behaviorist psychological theory, and state mandates. It is a view reinforced by research that is not relevant to the classroom; it is a view where standardized testing is used to judge school performance while blatantly ignoring demographics and inadequate funding; it is a view in which conflicting political mandates are imposed without an understanding of their relevancy or consequences; it is a view in which reformers, sincerely seeking to resolve turmoil, merely re-label past practices in the name of change; it is a view made cynical from a loss of trust and a blurring of ethics.

Cognitive illusions are imbedded in this representation. They are fundamental to maintaining the current fragmented, over-specialized content areas as practiced today. To create a curriculum in which knowledge is truly a tool rather than an end in itself, these illusions must be identified and replaced with a new awareness of how and when learning occurs. To do this, it is necessary to revisit what it means to think, to learn, and to know.

The reaction of most of the teachers already using the technology has been to copy what they have done in the past—using new media. The technology is as increasingly fluid as it is ubiquitous. A substantial shift in the structure of the foundations of education is necessary if a successful and lasting response can occur. This might be as simple as a creative execution of its uses and place in the curriculum. However, we must exercise care if we are to avoid destroying the bakeries of the institution in the process. I believe that the full nature of that shift is as unpredictable as the shift itself is inevitable.

In exploring these thoughts, I will cull recent ideas, theories, and wisdom from a number of authors within a variety of disciplines—from linguistics, philosophy, history, neurobiology, psychology, sociology, and mathematics. The newer ideas are mixed with others that are forgotten or on the verge of being forgotten. This break with tradition, by not drawing from educational literature when doing formal work in education, is consistent with the problem I am addressing—the imposition of technology on an unprepared culture. This deviation in practice is consistent with my belief that, no matter how narrow it is defined, education encompasses more than any one identifiable facet or aspect. This deviation is consistent with a practicing teacher's perception that the research literature lacks relevancy within the teaching experience.

For example, studies upon studies have demonstrated the effect class size has on learning and the ability of the teacher to attend to individual student progress. Yet administrators continue to dump students into already overcrowded classrooms with the illogical argument that the average class size is within the limits. That alienating doublespeak feeds cynicism when one realizes that that average (even if the computation had any initial legitimacy) is calculated using the number of certified personnel, not the number of classroom teachers. While the practice does not invalidate the research, it does make it irrelevant in the context of the classroom.

Throughout this paper I will use the word *constructionism*. The concept is also known as construc*tivism*. (e.g., translations of the writings of Piaget) A confusion rises, however, since the latter word is also associated with a postmodern social activist construct. To avoid confusion I have adopted the term and general sense suggested by Seymour Papert in *Mindstorms* (Papert, 1980). Briefly stated: Constructionism is the belief that individuals form their distinct knowledge of the world and self through a trial and error process. In the classroom the child learns by constructing upon previous learning as mediated through the teacher. It differs from current school practice (rote learning) in that the individual actively participates in learning.

With almost twenty years of teaching programming and computer applications behind me, I feel unsure about what the state expects. If I am insecure, what must others without experience be feeling? The state's expectations are couched in the usual jargon of our time—life-long learning, responsible citizenship, productive employment in a global economy. All worthy causes. Is what is said what is meant? In verbalizing goals, whether political or otherwise, there are at least two levels to the expectations understood in the goals. The obvious surface level can be taken at face value. It is the subtext that is worrisome. This subtext contains a condition that is not within the context of the effected culture. The condition assumes that the culture has a viable insight that will achieve a successful resolution of the goals. One is forced to conclude that the state does not understand the nature of the technology, the nature of the surface goals, and is certainly out of touch with the culture.

The question, however, is not whether the state is right or wrong—that has been decided: The wires already not in place are working their ways through the walls. The force has been unleashed. And, no one will deny the power a mouse click away from students. It is overwhelming. The school is truly without walls. The world is their classroom. Fine. What do teachers do with it? Never mind. Teachers are already doing *something*.

What *is* supposed to be taught? The hardware? Software? Even if *Windows 95* were the only operating system or whatever to access the internet, what do you teach after *clicking and dragging*, and the *menu bar*? What do you do after you have visited the Friends-of-the-Pythagorean-Theorem chat room? Roamed through the Louvre? How many home pages can one school generate? To what purpose?

Although it may read that way, I am not being facetious. I used the web in my research for this paper, and I'm grateful for the ease with which I found ideas that suggested ideas, authorities that led me to other authorities, and insights from academics that explicated the arcane. Without the bibliographies that accompanied on-line texts by such MIT luminaries as Sherry Turkle or Mitchel Resnick, I might not have been introduced to new ways of looking at the internet, constructionism, complex systems, and parallel processing—expanding my view of areas that had already interested me. My debt to the internet is enormous, but its contribution was only as a library function—a fast *Readers Guide*, a simpler *Index*. My experience strengthens my belief in the power available to serious students. I must ask, again: In the 12 or 13-year curriculum, where does it fit beyond the library?

This paper does not assume an arrogance that would infer that an answer to that question is possible under present conditions. Nor is the purpose of raising these questions only to debunk technology. At the least, that would be puerile. As I have said, the wires are in the wall or they are rummaging around in there somewhere.

In an interview with a principal and two teachers of a Mahoning County (OH) elementary school last summer, I asked how they were implementing the mandate. Proudly they displayed beautiful hypermedia and word processing artifacts. The quality of the art and the sophistication (for third grade) of thought impressed me. My mind conjured visions of little fingers tapping out the poems laboriously, hunting and pecking letter by letter. This was the *something* that was the culture's response to the state. Given the culture, the teachers had no choice. To paraphrase an axiom: If the only tool you have is a computer, all problems will have a word processing solution.

In the course of our conversation the observation was made that they were "making [their students] ready for the 21^{st} century." I smiled: I too have used the phrase repeatedly. When spoken with the sincerity and fervor of these women, I was immediately aware of an new incongruity. This awareness was not triggered by the application of a 19^{th} century conception using 21^{st} century technology: I had expected that. I am struggling with it in my own classroom. The epiphany was that the whole culture is in a time warp. It is in a cognitive illusion that technology will wait for third graders to enter the work place. This is an illusion predicated on the idea that it can take 12 or 13 years to teach the operation of hardware on some future device, not even invented—using the present, soon to be outmoded technology.

The argument that teachers are preparing the student for the 21st century implies that somehow schools know the needs of business. Everyone agrees that businesses would like potential employees to be ready for the workplace. It is what businesses expect that is the source of confusion. Most educators are not aware that businesses have demonstrated their ability to adequately train people in a current technology within hours of an individual's employment. In my experience on committees with business and industry executives during the preparation for the Trumbull County (OH) *Tech Prep* program, two skills were identified as paramount:

- communication—the ability to communicate ideas and to understand the ideas of others; and,
- interpersonal—the ability to get along with others.

These skills were not just at the top of brainstorming lists; they were the body of a mantra. My experiences as a middle manager twenty some years ago confirm that their importance to success has not changed over time. On the other hand, the quality, quantity, and modernity of technology hardware and software in the workplace is anything but uniform. It is chaotic. Businesses rightfully expect technical expertise from technical schools. Except for a broad and generic approach to technology, the rest of the schools generally *should concentrate on how to learn about and adapt to change*. Business is better suited to care for the specific needs of their own technology training.

On reflection, I realized that a second illusion manifested itself. Imagine the absurdity of the elementary schools teaching word processing (without teaching keyboarding) so that they will be ready for the middle school to teach them word processing (also without keyboarding) so that they will be ready for the high school to teach them word processing and keyboarding. Substitute hypermedia, desktop publishing, or whatever you like in this sequence.

In his book about how organizations learn, Peter Senge (1990) frequently quotes *Proverbs*: "Where there is no vision, the people perish." (28:18) In pointing this out, I am not implying that educators lack a vision. I do charge, however, that the vision they do have is buttressed by structures found in the sciences of the 17th through 19th centuries and the psychology of the early 20th. The structures of science and psychology have changed, but those of education have fossilized. It is widely accepted that the Pavlovian or Skinnerian theory of learning addresses only the animal level of cognition. It fits well with the rote learning used to judge schools—to hold schools accountable. It does not fit well with the un-testable higher level cognitive skills needed in the 21st century. Artifacts and social interaction best demonstrate those skills. Assessment cannot be of the cut-and-dried fill-in-the-bubble form universally practiced. The assessment of projects and relationships is subjective; it is fragile and controversial. It may very well be impossible to achieve. It may turn out that judgments will be made by committee.

Senge's analysis of vision implies the need that the vision be shared at the transcendental level. Using his broadest definition, teachers posses this quality. It is in the structure that supports the vision that change is needed. It is within the mental model whereby the teacher views herself and how she functions within the institution that the freedom to change will occur. It is the purpose of this paper to organize some elements from a variety of seemingly disparate disciplines to form a backdrop against which liberating ideas can play.

Within the fabric of that backdrop, the student must be understood to be the core of the fibers used in the thread. The child may not be immediately or always visible within this paper, but it is to be understood the presence is always there, for without that human element there is no purpose in any vision no matter how lofty. Too often the child is merely a pawn in the game of power. Horace Mann suggested that pupils were assets to be calculated when industry determines its capital worth or raw material. Today, parochial interests whose religious fervor and insularity match Luddite ferocity and ignorance consider them to be cultural assets. I suggest that if they are assets at all, they are assets of the species. To survive with its brain function, *mind*, the species must not succumb to an evolutionary atrophy that will be our fate if we allow a homogenization of our schools through curriculum.

Reformers demand a uniformity. They want the kind of predictability that gave rise to McDonald's. Food from the chain is predictable no matter which highway is traveled or how far the traveler is from home. Reformers demand that education in the United States should have the same predictability and, as some insist, the same bland flavor everywhere. While I have faith that the collective mind will eventually reject this, I wonder if the nation has the time to waste on a replay of a regressive experiment that failed the Church in Europe and the Puritans in our own history. While this paper does not address this question overtly, it is a shadow in the wings. More to the point, this paper does attempt to investigate a path for learning that reflects how the mind's *desire to know* can be enhanced.

Knowing is an idiosyncratic event. Whether it is defined within levels of consciousness or degrees of perception, it is a unique and human quality. It is a constructive intrapersonal and interpersonal process that may result in a good or an evil individual. From birth, language and culture modify the process. Both or either can frustrate the goal to *know*. Through a sensitive and sensible understanding of the process, the child can be nurtured through the stages of development without either suppressing or perverting the natural process.

The purpose of this paper is to develop some insights leading to defining a viable framework that could reconcile the conflict between the expectations implied in mandated changes in classroom technology, and the effects and educative suitability of those changes. Various states, supported by the Congress and the President, are mandating the use of computer related technologies, with special emphasis on the Internet. The teachers who are expected to implement this use are not just unprepared in the sense of technical training, they are unprepared in the sense of a structural vision. In this paper a reconciling framework will be built around five, interrelated perspectives:

1. To place the conflict in the context of uses of technology, past classroom experiences with technologies will be investigated. (Chapter 1)
2. To give understanding to the response that can be expected when this change is imposed on an unprepared culture, prevailing practices in instruction will be reviewed. (Chapter 2)
3. To provide lenses for viewing change, a mental model for understanding cognitive illusions and the four facets of education will be constructed using a soft geometry. (Chapter 3)
4. To provide a context for suggesting modifications, the learning process will be reexamined in terms of recent understandings in the cognitive sciences and relevant theories that have been abandoned over time in the name of efficiency. (Chapter 4)
5. To place the technology in the context of the classroom over time, the effects of software and hardware change will be narrated through personal experiences, and through a condensation of a major experiment featuring massive infusions of technology. (Chapter 5)

I am including a sixth chapter that is devoted to one possible structure for a *seamless* school. This formulation is based in a fundamental vision that a school must prepare students in a practical way for *change*. To do this, I create a school system that applies the constructionist theory suggested in the body of this paper to a *whole* educative milieu. This milieu is a coherent structure that services an individual's life span. Transitions are made on the basis of growth, rather than the current grouping criteria such as age or ability. The consequences of disruption caused by breaks within the normal progression are ameliorated by removing the social stigmas imposed by such arbitrary groupings.

CHAPTER 1—THE TECHNOLOGY EXPERIENCE

INTRODUCTION

Technologies used in early 20th century education were adaptations of non-educational inventions. Pioneering teachers introduced them in the belief that the technology held a potential for improving learning through novelty. The average classroom teacher eventually viewed them as legitimate aids to instruction. As studies seemed to prove them to be efficacious, use and acceptance expanded. Neither use nor acceptance approached the level of ubiquity that the pioneers prophesied. Lack of training in the new technique and costs were probably the main factors limiting full acceptance. This progression established a pattern.

Over time, each innovation followed that pattern as a newer technology replaced earlier, less effective technologies. By mid-century, technologies were introduced that married the dominant associative psychology theory with method. By the end of the century, various states, with the encouragement and direction of federal officials, were mandating the installation and use of computer related technology into the classroom. The nature of that mandate is such that the technology goes beyond the pattern of merely exchanging one technology for a better one; the nature of the mandate forces the classroom teacher to treat the technology as a tool for passing state mandated tests—an expensive tool for rote learning. Without serious and continuous training, the scale of the mandate will overwhelm the classroom teacher. Without a serious examination of how individual learning occurs, even the avowed goals of the mandating politicians will prove to be illusive.

Four of the six goals identified during the 1990 *Governor's Conference on Education* are directed at *educational levels of attainment* that cover the range of learners from pre-school through adult. By the year 2000, "'[a]ll children in America will start school ready to learn'" and "'[e]very adult will be literate and will possess the knowledge and skills necessary to compete in a global economy . . . .'" Furthermore, "'. . . students will leave grades four, eight, and twelve having demonstrated competency in challenging subject matter including English, mathematics, science, history, and geography . . .'" and students will "'. . . learn to use their minds well . . . .'" The state also expects that "'. . . students will be first in the world in science and mathematics achievement'" (Thornburg, 1991, pp. 14-15).

The U.S. Department of Education formally summarized the conference goals in its follow-up document *America 2000* (1991, p. 9). Typical of the many states that agreed with that program, the response of the Ohio General Assembly was to establish a two-pronged program: *Ohio SchoolNet* and *Ohio SchoolNet Plus.*

Ohio SchoolNet ". . . calls for the wiring of every classroom in each school building in every public school district in Ohio with at least one telecommunications connection that will allow for voice, video, and data communication" ("About *Ohio SchoolNet,*" 1997). The initiative provides $50 million to install the necessary wiring. Another $45 million is earmarked for computers and peripherals to be placed in the poorest schools (25% of Ohio schools).

SchoolNet Plus targets the K-4 population with $400 million. This fund is intended to provide ". . . at least one interactive computer workstation for every five Ohio public school students . . . " in the target group ("About *Ohio SchoolNet Plus,*" 1997). Each district will control the exact technological mix as long as purchases are consistent with the goals of the legislature and within the terms of the district's state approved technology plan.

SchoolNet and *SchoolNet Plus* introduce a new reform dynamic. Without too much exaggeration, the *SchoolNet* mandate is analogous to a mythical situation where the bicycle had been invented a few years before and the state decides that, as a minimum competency for transportation skills, every child will know how to ride a bicycle. As a minimum, the state issues a bicycle drive chain to every family with children. Poorer families are issued the complete bicycle. The families receiving only chains will be required to supply the gears, wheels, and frame; the poorer families order bicycles with head lights, bells, carrying baskets, and ten gear speed capabilities.

Of course, before the child can be taught bicycle riding techniques, the parent must learn. Parents are gathered together in state sponsored workshops and an expert demonstrates how she maneuvers over rough terrain and in tight places; expanding on the possible limitations of bicycle riding, she expertly executes wheelies, and spins. An hour or day

later, at home, the parents with drive chains are still unsure how they connect to the gears, or even if they have purchased the right configuration of wheels and frames.

Meanwhile, the Wright brothers have moved out of their bicycle shop and invented the Aeroplane.

The Technology Plan for the Liberty Local School District is typical of those submitted for approval by the state from school districts. A committee of teachers and administrators developed it during the 1993-1994 school year (Technology Committee, 1994), and modified it slightly in 1996 to conform to the state model. The plan outlined an action-time-line that identified the major goals, objectives, and strategies in the six areas of staff development, curriculum development, student achievement, administrative support, networking, and community outreach. Since the areas are interdependent, the funds can be expected to reinforce the effectiveness of the program with the installation of this key support infrastructure.

It should be noted that, while the mandate contains an infrastructure supporting staff development, without a strong philosophic and financial commitment to the efficacy of *continuing inservice* (beyond the initial funding), any massive influx of technology can only be overwhelming to under-trained teachers. Such training, however, must not succumb to the traps experienced during the deployment of earlier technologies. To understand the pitfalls that were experienced, it is helpful to investigate the conditions of their implementation.

CLASSROOM EXPERIENCES WITH RECENT TECHNOLOGY

Recent technology is defined here as that which came into use since 1900. Since these technologies have entered the classroom with similar over-exuberant advocates who wildly declared that their particular discovery was the panacea that would solve the ills of education and, in some cases, replace teachers, it is not necessary to document each. Film, radio, teaching machines, and computers (after 1990) will be highlighted at the expense of filmstrips and slides, phonographs and tape recorders, and television. Although somewhat arbitrary, I believe that what can be said for film can be said for television; what can be said for radio can be said for tape recorders; and, what can be said for teaching machines can be said for the early uses of computers.

For all intents and purposes, the course of events is so repetitive that film can stand as exemplar. The pattern is one in which a technology is introduced into education by a small group of enthusiastic practitioners; with very little or no collateral support users must prepare their own amateurish materials; after more sophisticated ancillary components are in place and criticism increases, detailed studies are made which invariably support use and further study; teachers fail to incorporate the technology in their practice; and, another technology is introduced with enthusiasm (Tyack & Cuban, 1995; Cuban, 1986; Saettler, 1968; Suppes, 1966).

Film

Early in the 20th century, the potential of adapting the fruits of the burgeoning silent film industry for educational purposes became the focus of teachers who were willing to experiment and innovate. If the new technology was to be of any benefit, at the very least it had to be an aid to the classroom teacher (Saettler, 1968). Thomas Edison summarized the expansive enthusiasm of early advocates when he declared that "'the motion picture is destined to revolutionize our educational system and supplant largely, if not entirely, the use of textbooks (Wise, 1939, p. 1).'" However, the advent of hardware in the form of projectors for motion pictures was not without precedent. Even without electricity, the magic lantern (introduced in Rome in 1646) and the stereoscope were available by catalog in 1874 (Anderson, 1962).

Although a catalog listing over a thousand items was published in 1910, the initial use of motion pictures was somewhat hampered in that films prepared especially for education did not exist. Teachers made do with the what was available even when what was available was not always totally suitable. Material, no longer having commercial value, was re-purposed and sold cheaply for the classroom. However, by the end of the second decade, the quality of films for the classroom improved as a result of the need for market expansion by commercial producers who were actively providing training films for industry and the military (Saettler, 1968).

As with any change in education, enthusiasm for motion pictures was not universal. Some objections were philosophical. The main reluctance rises from the early use of subject matter that was originally intended for the entertainment industry. Later, free advertising films were considered too narrow or one sided for the classroom, confirming a wide spread reluctance based on content. However, there were concrete obstacles to effective use of the medium. Along with the cumbersome and stationary nature of the first projectors, the volatility of the early celluloid base presented a real danger from fire in the school building (Saettler, 1968, p. 98).

There were other practical reasons for teachers to be slow to actively include film in their practice. In his review, Cuban summarizes the problems that appear across the literature:

- Teachers' lack of skills in using the equipment and film
- Cost of films, equipment, and upkeep
- Inaccessibility of equipment when it is needed
- Finding and fitting the right film to the class (Cuban, 1986, p. 18).

These problems sound familiar since they continue to plague teachers to some degree today. The list need not be viewed as applicable only to films; it can apply to later technologies. Only a few nouns need be changed.

The question of the educative value of motion pictures in the classroom rose early. Two studies, one from 1929 and the other from 1939, will help give an understanding of the teaching culture in that period. The first centers around 20 films used in General Science and Geography. The technology did not include sound, but title screens interrupting segments and sub-titles during action sequences were common. The second included sound, but internal evidence of the report indicates that text continued to be incorporated visually in the body of the film. The study itself addressed only one subject: history.

Motion Pictures in the Classroom, the first of these studies, sought to ". . . [ascertain] the nature and extent of the influence of the films on the attainment of the accepted goals of sound classroom practice, as these have usually been measured and observed" (Wood & Freeman, 1929, p. 1). The Eastman-Wood-Freeman experiment, as it was called, was sponsored by the Eastman Kodak Company who undoubtedly wanted to support their investment in films for the classroom.

Twelve cities located in the northern, southern, eastern, and western regions of the country participated. The experimental classes were generally not in the same building as the control group, since it was believed that separation of the students and the teachers would lead to cleaner results. Five to seven page highly detailed outlines were given to both groups as study guides to ensure content consistency. Using a variety of formats (true-false, multiple choice, two-word answer, and essay), tests were administered at various stages throughout the experiment.

From their data Wood and Freeman found a measurable difference in favor of the experimental group. Moreover, they found that films are especially strong in supporting ". . . the child['s] clear-cut notions of the objects and action in the world around him (p. 21)." However, as they point out:

> This is not to say that the ultimate effect of the film is confined to the development of concrete ideas. To draw such a conclusion would be to ignore completely the fundamental relationship between direct experience and thinking. The pupil can think effectively only when he has adequate material with which to think. Superiority in direct experience, then, should increase the effectiveness of the pupil's thinking, and our evidence confirms this expectation (p. 221).

Motion Pictures as an Aid in Teaching American History (Wise, 1939), the second study, involved 26 classes in five high schools in Missouri. While not as ambitious in scope as the Eastman-Wood-Freeman experiment above, this study looks at differences in student attitudes in addition to the effectiveness of film on retaining information and understanding. In general, where the studies were parallel, the conclusions were similar, i.e. films help students in understanding the content of the topic addressed.[1]

When reporting on student attitudes toward history, Wise finds that both groups, experimental and control, increased in their appreciation of history as a subject, with the experimental group ranking history higher than the control group[2] (p. 112). This side effect seems to be considered unremarkable and no explanation for it is given.[3]

As in the Eastman-Wood-Freeman study, the preparation of ancillary materials was done by the study staff. To maintain consistency, most of the routine was removed from burdening the teacher. Specific conditions were outlined (e.g., detailing the position of the screen and its size [p. 151]). As part of the list of instructions, teachers' concerns or objections were neutralized; sometimes redundantly; sometimes patronizingly:

> 3. It should be made clear to the students that there is no fire hazard because Photoplays[4] are on sixteen millimeter non-inflammable film which will not burn or explode . . . .
>
> 4. Each teacher will be taught to operate the portable projector to be used in her room. Sufficient skill in the operation must be acquired that the mechanics of projection will not be a distraction from the Photoplays . . . .
>
> 6. Both films and projectors will be inspected regularly and kept in good condition to guarantee the best possible projection. If the projection becomes unsatisfactory it should be reported at once so that a check of the equipment may be made and the condition remedied . . . (Wise, 1939, p. 151).

In a follow-up chapter to his conclusions, Wise points out that even outside the experimental milieu there is more to showing a film. For the teacher *showing* a film is just a small part of what must be done in preparation and follow-up. The specifics he cites are exemplary, lengthy, and detailed. He summarizes these, expressing them expansively, mixing conclusion with theory, and echoing Edison:

> The motion picture is an instructional tool of tremendous power in the accumulation of knowledge and ideas and in the development of attitudes and appreciations . . . . However, as a tool for history teaching it is not a method or an end in itself but a supplementary aid. The motion picture can never be more than a supplementary aid until the framework which links a series of historical incidents together no longer needs to come from books. The teacher's first task is the teaching of certain topics or units, and her second one the using of various teaching aids and devices (p. 142).

The enthusiasms and conclusions suggested by these and other experiments did not translate into the classroom use. Into the 1950's some teachers used film on an average of once a month if at all (Cuban, 1986, p. 16). The reasons that Cuban outlined (cited above) remain even after the introduction of portable video tape players made the use of television easier.

Radio

On May 6, 1997, the PBS news program *All Things Considered* aired a 60th anniversary re-broadcast of the burning of the zeppelin *Hindenburg*. At the time of the tragedy, the event was captured on film and theater patrons were able to watch it in the remote comfort of plush seats in a darkened theater days after the event. That live radio program, on the other hand, placed the first disaster to be broadcast in the listener's living room as it was happening. Herbert Morrison's emotion filled narration wrenches the listener today, even after hearing recordings of it many times over the years.

From the beginning, radio was immediate. The event, the voices, the significance were all converging at the same time—in real time. Some teachers were quick to realize the potential but events refused to cooperate (Laine, 1938). A *Fireside Chat* just did not happen to coincide with the 10:37 A.M. *American Government* class.

In contrast to radio, films had a remote, illusory quality. In the early years historical and literary events were recreations having an air of unreality about them. The artificiality was emphasized when exterior scenes of real trees, rivers, and hills were followed by interior scenes having painted architectural features. When the scenic elements became more realistic and sound was added, and, as footage of contemporary events, such as the burning of the *Hindenberg*, accumulated through news organizations, presentations were more believable. However, a remoteness remained that was not dispelled until television brought the Vietnam War into the family room.

The psychological difference between being in a darkened classroom watching Congress in action on a two dimensional screen or being in a lighted classroom listening to a congressional debate as it unfolded was the motivating difference that the pioneers envisioned. Radio enthusiasts were frustrated and many teachers were turned off because what they got was a congress bogged down in a tedious thirty minute roll call (Levenson, 1945, p. 51).

The initial instructional broadcasts for schools originated in commercial stations and were lectures of a practical nature. C. Marcus Wienand gives us a flavor of the times as he describes the first such broadcast:

> In April, 1923, the New York City Board of Education performed this experiment. A lecture on machine accounting was broadcasted by station WJZ of New York City, and picked up by a class in accounting in Harlem High School[5] of that city. Part of the lecture consisted of problems to be worked out by the listening students on their calculating machines. The large number of correct answers from the pupils was a direct measurement of the efficiency of this method of lecturing as far as the individual class was concerned, not to mention the limitless number of other classes that could have received the same lecture (Wienand, 1932).

A second direction that radio technology could utilize was defined a year earlier in the Buffalo, NY school system. "Vocational School pupils built a complete radio station which was utilized to broadcast programs by pupils from the city's schools (Levenson, 1945, p. 51)." These non-commercial broadcasts focused on the goals of the curriculum and only incidentally on student involvement. This distinction, of making the student the participant in a real event with the technology as opposed to the student as passive participant in a technology purposed to assist the teacher, was not considered at the time.[6]

Commercial radio soon dropped the instructional form of educational broadcasting in favor of one that was more in line with its entertainment mission. These took the forms of quiz shows, concerts, and historical dramas.

Capitalizing on the untapped teen age talent reservoir, nation-wide broadcasts like Dolf Martin's *Youth on Parade* featured only young performers. Originating at WEEI in Boston during the late thirties and early forties, the Saturday morning performances featured a potpourri of short dramatic skits interspersed with stirring choral music designed to celebrate American youth before and during the war. A live and enthusiastic audience gave the show more credibility. As a frequent member of the audience and as an after-performance stage door johnny, I can testify that patriotism and moral literacy were effectively taught without a curriculum guide.

Commercial radio was abandoned by the schools primarily because it was just that—commercial. Unlike the British Broadcasting Corporation, American commercial radio depended upon subsidy from commercial interests. School budgets were too limited to "engage the time of the commercial stations with any regularity (Emery, 1932, p. 62)." Furthermore, the commercial was viewed by educators as a form of propaganda as odious as that of political or nationalistic bias (Laine, 1938).

The earliest question of the purpose of radio use in the school was more one of who was to be educated by the technology. That framework identified with the accumulation of facts within a lecture format:

> Research and experimental work must be done in determining the groups of people to be educated, the subjects to be given, and the selection of speakers.
>
> The question will be ever present—Whom do we want to educate? First thots [sic] would lead one to the idea that this form of education would be unsuitable for children, on the plea that children need the personal touch, but on second thots, when we remember the experiences of educators with movies in schools we can feel assured that radios in schools will do at least as much to stimulate interest and hold attention as the movies and phonographs have done . . . .
>
> We should judge that talks on scientific subjects would be specially popular, but the popularity of any subject will largely depend upon the gifts of the speaker. Some have the genius to make people think . . . .
>
> It must not stop at broadcasting knowledge already accumulated in books but must distribute new knowledge as acquired . . . (Hewett, 1932).

Divorcing themselves from commercial radio, boards of education and universities created schools of the air. In doing so they found it necessary to define their purpose. That purpose was expressed through their programming, which meant through the scripts used for programs. William Levenson who directed the activities of WBOE, the radio station of the Cleveland Public Schools, explains:

> A school radio script begins with a purpose and not with a form. What effect upon the learner do I want to create? the writer asks. In this program, am I primarily concerned with the acquisition of facts, concepts, and principles or have I another aim in mind? The goals of the radio visit may be multiple but some

> primary target must be established. Do I want especially to create appreciations and emphasize attitudes? Is my basic purpose at this time the building of broader interests? Shall I try to stimulate pupil investigation? Is my chief object the development of critical thinking and discrimination? Once the desired end of the broadcast has been determined, the writer can turn to the means, that is the content and form of the script (Levenson, 1945, p.48).

Repeating the experiences of those who advocated the use of film, radio projects fell short of the expectations of its advocates. It did not translate into anything near the universal classroom use that had been prophesied. With time another technology replaced radio and a pattern was emerging. Saettler summarizes the wane of radio:

> By the middle sixties, publications and research relating to instructional radio had virtually ceased; course offerings in radio instruction were considerably reduced; commercial radio networks had closed their radio education departments and discontinued their school broadcasts; and the once-vigorous leadership of the Radio Section of the U.S. Office of Education had disappeared. It was evident that educational broadcasting was shifting its focus from radio to television. Whether intentional or not, radio instruction by the sixties had become the stepchild of instructional technology (Saettler, 1968, p. 226).

The evidence indicates that, even at the height of usage in the late twenties and throughout the thirties, classroom use of radio was sparse at best (Cuban, 1986; Saettler, 1968). This lack of formal influence should not be taken to mean that the educative value of radio was not exploited. The early education stations and education oriented commercial stations evolved into the public radio networks, pioneered by stations like KDKA in Pittsburgh and WGBH in Boston. They influence and educate a larger audience.

Film and radio did not fail to be incorporated in the classroom because they were ineffectual as instruments for expanding the teacher's array of instructional tools. Teachers readily understood the support that the technology would provide in impressing ideas and demonstrating concepts through the senses. These technologies failed to catch on because they were costly and required training. The expenses—to school boards in terms of sufficient equipment, and to teachers in terms of invested time—were too high in education's bake sale economy and mind set.

Programmed Machines

From the beginning of the 20th century, a very subtle change in the institution education had been taking shape. With roots that extend into the 16th and 17th centuries, two ideas were converging: Learning is a body of facts; and all things can be measured.[7] These two, seemingly unrelated ideas, came to be technologically embodied in a machine described by Sidney L. Pressey of Ohio University, its inventor, as a "'simple apparatus which gives and scores tests—and teaches (1927).'" The symbiotic relationship between testing and teaching had evolved into a paradigm that allowed a teaching technology by ukase possible today—a teaching technology imposed through the edict of a new kind of tzar.

Unlike film and radio, the teaching-and-testing machine appeared with educational credentials. Film and radio were the children of the entertainment industry—the source of pleasure and artificiality; These machines came from scientific invention in the university. However, the imprimatur of educational academe was not quite enough to effect a rapid easing of the technology into the classroom. This did not happen until the sixties and it took the authority of B. F. Skinner to do it.

Pressey and others were trying to improve (against the backdrop of their understanding) some of the vexing mechanics that makes teaching and learning difficult.

Primary among these was the seeming contradiction that occurs when trying to satisfy individual differences in a group setting.

When the machines finally were used in the classroom, 40 years after introduction by Pressey, Benjamin Fine, one of the later advocates, advances assertions even more extravagant than those made for previous technologies:

> For the first time in the history of mass education, the machine's *aficionados* argue, the way is open for us to treat each student as he really is: as an individual. No longer must he be forced into one rigid lock step with the rest of his class. If he is exceptionally gifted, we can educate him exceptionally fast. If he is slow, we can educate him slowly and well. Unlike his distant and recent predecessors, the new student will neither be retarded nor pulled ahead too quickly by his schoolmates. The truly wonderful thing is that regardless of his ability, he will learn faster and better than he ever did before.
>
> This achievement has been the hope of educators for decades. How, they have asked, do you educate millions of people in a democracy with precise regard for their individual talents? For decades we simply didn't. Now it looks as if psychologists have found the answer in the teaching machine (Fine, 1962, p. 20).

That paradox, that individual needs can be met while being taught democratically *en masse*, was not the only conflict that the machine resolved. A panacea for other ills had been found: The turn around time between taking a test and receiving the graded results was shortened; and its companion problem, immediate response after answering a question in the teaching environment was also achieved. Both problems were receiving the attention of associative psychologists with B.F. Skinner foremost in the research. The authority of operant behavior's founder thus gave the movement the kind of impetus that made it a serious option for improving education. So strong was Skinner's identification with what became to be known as programmed learning that his name was given to the class of successors to the teaching machines Pressey and others had pioneered (Lumsdaine and Glaser, 1960).

Broadly defined, programmed learning was implemented in two ways: through the teaching machine and through books. Each of these methods had its own sub-types. The underlying and unifying rationale was embedded in associative psychology centering on reinforced stimulus and response (S→R). "[N]ew methods of shaping behavior and of maintaining it in strength . . . (Skinner, 1960, p. 100)" originated in experiments involving pigeons, but could be ". . . brought to bear upon practical problems in education (p. 107)." The process, known as operant conditioning, came to the classroom as a culmination of the influences of behavioral psychology.

As pointed out earlier, the first machines were being developed in 1925 and succeeding adaptations followed the pattern set at that time. In general the fact to be learned or the question to be answered was set forth in a window (frame) and the associated activity was performed by pressing a key, punching a hole, or applying chemicals to spots on a companion paper. If the response was correct, the machine allowed the student to advance to the next frame. If incorrect, the student would be given an opportunity to retry or (in sophisticated machines) the student would be branched to a remedial activity.

An alternative to machines took the form of printed consumables—workbooks. In one format a cardboard window isolated each frame, and the student would record the answer in the workbook margin. The student received feedback by manually sliding the window to the next frame where the answer appeared. The obvious question of how cheating was controlled in other than a one-on-one situation is not satisfactorily addressed in the literature:

> The programmed textbook is a simple means for presenting machine-teaching type learning sequences without hardware. The device meets most of the critical requirements of machine teaching, but it cannot prevent cheating. However, it is concluded that, not only is the influence of this variable largely unknown, but it occurs with such infrequency in an adequately constructed program that its importance is likely to be small (Homme and Glaser, 1959, p. 107).

A more sophisticated alternative did make cheating more difficult. Norman Crowder developed a format which he called the intrinsic programming technique. This structured approach was recursive and was successfully demonstrated in the *TutorText* which is:

> . . . a specially prepared book in which each answer choice is identified with a page number. The reader, choosing a particular answer, turns to the page number given for that answer. There he will find either the next unit of information and the next question, or, if the answer he chose was incorrect, he will find the correctional material appropriate to the answer he chose. He will then be referred to the original choice page to try again. The page numbers in the book are assigned essentially at random, and the reader, therefore, cannot progress from one page to the next except by making an active choice of an answer (Crowder, 1960, pp. 286-287).

In spite of the denials of its advocates, this technology is mostly effective in rote learning. Facts are laid out in small *chunks* that are easily assimilated. Each chunk had been analyzed by a programming team for its suitability as a support to the desired concept or *terminal behavior* and could involve anywhere from 1,000 to 25,000 frames (Glaser, 1961). Because such a format strongly supports algorithmic thinking, it is successful in mathematics and science. Its goals are strictly behavioral (Lumsdaine, 1961).

The teaching machine may have been an efficient tool for individualizing some of the learning in the classroom. However, that efficiency was a function of cost. The most effective devices were also the most expensive. When these devices were wedded with audio/visual components their cost rose proportionally. In 1962 prices for the popular machines ranged from $20.00 to $5,000. Books ranged from $3.95 (*TutorText*) to $15.00 (Grolier) (Fine, 1962, p. 147). It was obvious that text would win in such a one sided contest.

By the sixties a new kind of programmed learning machine was being introduced—the computer.[8] Here was a machine that might be cost effective. It could be used, not only for programmed learning in the classroom, but everywhere—throughout the school: in laboratory experiments, student guidance, registration, scheduling, report card preparation, fiscal records inventory, and administrative planning (Carter, 1962). The technology of time sharing would make all this possible through one master computer.

Challenges to the behaviorists were already beginning and among them a new idea was coming to the fore—Cybernetics.[9] Pioneered by Norbert Wiener in the thirties and forties the fledgling science studied feedback systems in machines and humans (Gardner. 1985). These early investigations eventually branched into two seemingly disparate forms: robotics and computers. Both, however, held the commonality of being programmed devices and would merge again in Artificial Intelligence studies. Because of the obvious parallel through programming, computers were seen as the successor to the teaching machine and programming efforts moved on to the new machine, taking with them the mind set and educative biases that made the abandoned technology successful.

By the late sixties a strong connection was being made between the computer (cybernation) and its effects on the society and an expanding need for a reaction by the society through education.

> [C]ybernation puts enormous burdens on the leadership of society, for the efficient and humane use of cybernation will require a much larger number of people displaying a far higher level of wisdom than is found in the leaders of our society, or indeed in those of previous societies (Michael, 1967, p. 9).

With time, the new machine invaded the curriculum. That invasion took two forms: computer assisted instruction (CAI) and computer as subject.

CAI is known by a variety of names that reflect the technological or instructional format that is employed. The largest class employs an instructional design inherited from the teaching/testing machines developed by Plessey undergirded by Skinner's operant behavior theories. Over time other technologies were combined with the computer in the teaching machine format. Thus interactive video CAI uses video controlled through the computer, and interactive multimedia CAI may employ hypertext, video, laser disks, CD-ROMs in any combination with the computer.

The flexibility of the computer allowed for other CAI formats which had their origins in the training methods used in industry or by the military. Simulations, for example, were inspired by projects developed in the military. These programs with their game-like format heralded learning theories that were only on the fringes of education in the sixties and seventies. Teachers trained to believe that learning could not be fun were uncomfortable with the game format.

The technologies that have been discussed to this point were understood to be adjuncts to the curriculum. As pointed out before, students were involved in radio, but what they were doing was considered as a part of the communication function of the English department not as a curricular stand alone. Early in its introduction those who advocated the computer saw that it was not just another teaching machine. Social arguments based on an increasing ubiquity such as Michael's may have been sufficient to make it stand out, but methods of its introduction into the school also contributed to the uniqueness of how the computer was perceived.

Initially computer programming was the pathway whereby the curriculum would be expanded. The path taken was circuitous but the journey was rapid. Bill Gates (1995) begins his *The Road Ahead* with: "I wrote my first software program when I was thirteen years old (p. 1)." As an extracurricular activity, the computer time he used was purchased in the late sixties with ". . . proceeds from a rummage sale[10] . . .(p. 1)." earned by the Mother's Club of the private school he attended near Seattle. By the mid-seventies, schools like Liberty High School installed keypunch machines using FORTRAN in formal programming classes (Shellenbarger, 1997). In the late seventies the computer became its own subject under the general rubric *Computer Literacy*. By 1985, thousands of teachers and I were teaching classes in computer applications (word processing, data bases, and spreadsheets) as well as programming (BASIC, Pascal) on microcomputers in well established and unique *departments*.

The Internet and Learning through Links

In *The Phenomenon of Man*, the Jesuit paleontologist Pierre Teilhard de Chardin (1955/1979), expands the popular view of Darwin's theory to a state somewhere beyond *homo sapiens* as the end of evolution. His thesis, as I interpret it, is that, through evolution, the universe is seeking to understand itself. One of the experiments in that search involved the creation of life from inert matter and through a series of blind attempts evolved an intelligent agent (*homo sapiens*) who was only one step toward the Omega Point—the point where the universe understands itself or (being a Jesuit) is united with God. The cycle from the initial state of ignorance composed of inert material to final state of pure intelligence also composed of inert material would be completed. That concept obviously lies well within the realm of the metaphysical and beyond the apparent concretions of empirical thought. However, I find his vision a convenient analogy to describe an entity that is a transitional state between the abstract and the concrete, a system that is ephemeral at best, an entity or a system that is beyond the physical: the Internet.

Defining the Internet as merely an entity or as a system is inadequate. It is obviously a physical something that, in spite of the swirling electrons, is inert. Parts of this physical something can be identified as being in space and time. But there are elements that appear to make oxymoronic the space and time relationships as usually understood: In space it is at once local and ubiquitous; and, in time it occurs in real time and contains its own history. If the ability to store knowledge (however that may be defined) is one characteristic of a something exhibiting intelligence, the Internet with its billions of stored facts can be minimally said to border on that part of intelligence—surpassing the brain in capacity. It truly exists at the edge of de Chardin's noosphere (the region between man—the psychosphere—and the Omega Point)

This digression into a metaphysical analogy is intended to shadow the need to go beyond how we understand curriculum and instruction in any discussion of technology in education. Herein lies the murky region behind the dilemma that *America 2000* implementation poses in the classroom: What is to be done with these wires that the state has ordered dropped through the ceiling and onto the teacher.

While at the heart of that quandary is the Internet and its cousin, distance learning, there are more fundamental questions that seem to have been ignored. Larry Cuban(1997) shapes the problem when he would initiate a line of dialog asking that those who impose technology review the way they understand the uses of computers in the classroom. He suggests that they hold three biases that they must address in their thinking: ". . . [their] beliefs about the nature of teaching, [their] conflicting purposes of schooling, and [their] uncritical embrace of every technical enhancement (p. 41)." He views the quandary that high powered technology presents as one where the reformers:

> . . . might think creatively and reframe the problem of low-tech teaching as not of resources, but a struggle over core values. Reframing the problem would let us see it as a dilemma of conflicting values—those of techno-enthusiasts who seek efficiency and preparation for a computerized workplace vs. those who are unconvinced that higher productivity is better for students or meets the social purpose of building literate and caring citizens. Wiring schools, buying new machines and software, and sending teachers to workshops has little to do with this dilemma. Nor will blaming or shaming teachers into using computers work. Value conflicts seldom succumb to technical fixes (p. 41).

While these questions must be faced, it may be too late to frame an immediate dialog along these lines. The workmen are already crawling around in the ceilings and walls of the building. The wiring, the buying, and the attendance at workshops is under way. It may be more productive to define the nature of the technology, examine how it is currently being used, and then revisit the three points Cuban raises in face of this current reality.

The Ohio *SchoolNet* mandate cannot be defined in terms of only wires and computers, although it does require a system that employs "voice, video, and data communication" capabilities in every classroom. There is more to it once that mandate is interpreted to mean universal Internet access. This legitimately gives rise to the question: What is it—this Internet?

There are two metaphors that are used to describe the Internet: the ocean and the highway. In the ocean metaphor, there is the element of play and fun as one leisurely skirts about the edges, *surfing* from virtual place to virtual place. Access is achieved through the metaphor of the highway by using *on-ramps* through *gateways*. In its serious modality the Internet is a superhighway connecting the user to knowledge troves which could be sited anywhere in the world. Many of these sites can be accessed using a hypertext bridge called the World Wide Web. As the word hypertext suggests, the bridge uses graphics, sound and video, as well as text as the media through which knowledge is passed on to the user.

The Internet began as a research tool whereby the government and the university could share data. Since the university exists beyond political borders, data were passed internationally and eventually the nature of the data shared and those sharing data expanded into a network of networked networks (Krol, 1992). That complexity, daunting as it may appear at first, is the very reason why it could and should be an ideal tool for use in the curriculum; why it could and should improve instruction.

Unlike radio, film, and programmed learning technologies, the Internet requires some kind of deliberate interaction if any useful learning is to take place. That action/learning can only be done by the student: The student must be internally challenged for engagement; goals (or however the purpose of any learning is defined) must be generated from within the student; strategies for achieving the goals must be developed by the student. The Internet allows that kind of construction.

Describing the teacher's role in this milieu only as a mentor, as some kind of resource, or as the stimulating agent misses the point that the school with the Internet differs in major ways from the entity we understand today. Unfortunately, the view being held by many reflects a culture that is hamstrung by its past. Frequently, the Internet is being seen as a glorified medium for pen-pal communication in a real time virtual reality and an opportunity for shallow public relations on hypertext home pages. As interesting as these and other similar projects are, the purpose of the activity can only be educative if it is productive, leading to student learning—not just an opportunity to focus on a charismatic teacher.

SUMMARY

Until recently, the process by which technology was introduced into the classroom followed a similar pattern. An innovation in the general market place was brought into the classroom and adapted for educational purposes by resourceful and enthusiastic pioneers. Because adoption of anything new was mostly optional, the introductory process was slow and use was far from universal. Cost alone was not always the deterrent, but, combined with a lack of training, most teachers avoided novelty until it was well established by others.

From the earliest periods of innovation experimental studies follow the initial efforts of the trailblazers. These were designed to give the technology validity within the school setting. Most studies support the innovation. However, some studies can be considered suspect since they are funded by the related industry. Within the many experiments, the methodology follows the dictates of associative psychology, and those technologies that affirmed that bias of the method were understandably found to be best for education. In that context, it is not surprising to find that the computer, when used as a tool for rote learning, is the mandated technology of choice by the state.

The pattern for introducing technologies is also characterized as one in which each innovation is succeeded by another, better innovation. For example, film and radio were overshadowed by the VCR that seemed to be giving way to the laser disk which in turn may be in the process of being overcome by the CD ROM. These latter technologies are not easily pinned down because of the rapidity with which the changes are occurring. The pattern had a natural development of it own. It was evolutionary in nature. With the introduction of technology by mandate, the state has interrupted the process. It has created a new genre of *something* within the school. Is this something a subject? Is it a tool? Is it both? *Or*, will it prove to have the unintended consequence of fixing 1997 technology in the school for the next twenty-five to fifty years?

CHAPTER 2—EDUCATIONAL PRACTICE

INTRODUCTION

The facts from news accounts are uncomplicated and easily summarized. In Fairfield Connecticut, a bedroom community of 53,000—an hour from New York, someone in Stratfield Elementary School cheated on the 1996 *Iowa Test of Basic Skills* (ITBS). Eighty-nine percent of erasure changes on the answer sheets altered incorrect responses, correcting them. In the ensuing investigation, the principal became the prime suspect. A year later, investigators discovered that the 1993, 1994, and 1995 *Connecticut Mastery Test* (CMT) answer sheets from that school had also been altered (O'Neill and Lavoie, 1997). And Stratfield is not an isolated incident. Barker (New York), Chicago (Illinois), and Kaaawa (Oahu, Hawaii) also reported incidents of tampering of one kind or another (Lawton, 1996).

The implications of altered test results go beyond isolated incidents such as these. The concept of standardization—that all tests of a type are given under the same conditions will yield the same results—is in question. Any deviation from the established system challenges trust in the whole system. Tests that are reported in the media such as the ITBS, the CMT, or the SAT/ACT are especially sensitive within the school culture. It is not necessary to be close to education to be aware that the way schools are judged is through standardized testing.

Declarations about the success or failure of schools are announced in the Rose Garden of the White House, proclaimed in the wells of Congress, broadcast through the diversity of the media, and prayed over in the pulpit. Each pronouncement is buttressed by data drawn from the publication of results of standardized tests. Each pronouncement is made to appear to justify the policy or argument of the moment. Each pronouncement points up the unconscious belief that the essence of education can be embodied in testing—that success or failure in learning can be identified through quantification.

The causes for this cheating are found within the school culture that revolves around testing—standardized testing in particular. In Western culture, interesting enough, assigning a value to student work is only two hundred years old. "In point of fact, the first instance of grading students' papers occurred at Cambridge University in 1792 the suggestion of a tutor named William Farish (Postman, 1992)." From our perspective there is nothing remarkable about this, but as Postman points out "To say that someone should be doing better work because he has an IQ of 134, or that someone is a 7.2 on a sensitivity scale, or that this man's essay on the rise of capitalism is an A- and that man's is a C+ would have sounded like gibberish to Galileo or Shakespeare or Thomas Jefferson (p. 13)."

While testing is at the core of modern school culture, its centrality is supported by the primacy of the scientific method and its stepchild, scientific management. Legislators would not have reached the conclusion that entry to the 21st century could be mandated through the key of technology without an entrenched faith in science. It is in such a climate that the classroom teacher's response to *SchoolNet* can be anticipated. That reaction can be expected to be driven by the nature of this culture. It will also be motivated by the teacher's perception of themselves and their role in the greater society.

COGNITIVE ILLUSIONS

As pointed out in Chapter one, two ideas found convergence through programmed learning and in the teaching-and-testing machine. One is deeply seated in the belief that discrete nuggets of fact are the essence of learning. The second is rooted in a confidence that all things can be measured if approached scientifically. The primacy of facts as the core of curriculum and instruction will be addressed later in this chapter.

The concept that reality is understood through measurement is a Western construct. It comes to us through early thinkers like Thales, Protagoras and Aristotle. David Bohm (1980) suggests that their concept rises out of a division in the understanding of the meaning of the word *measure* that had occurred as languages evolved in the East and in the West:

> [I]n Sanskrit (which has an origin common to the Indo-European language group) there is a word 'matra' meaning 'measure', in the musical sense, which is evidently close to the Greek 'metron'. But then there is another word 'maya' obtained from the same root, which means 'illusion'. This is an extraordinarily significant point. Whereas to Western society, as it derives from the Greeks, measure, with all that this word implies, is the very essence of reality, or at least the key to this essence, in the East measure has now come to be regarded commonly as being in some way false and deceitful. In this view the entire structure and order of forms, proportions, and 'ratios' that present themselves to ordinary perception and reason are regarded as a sort of veil, covering the true reality, which cannot be perceived by the senses and of which nothing can be said or thought (p. 23).

Thus, Eastern thinkers observed a withiness—something illusionary—a unity to a whole that is not measurable; Westerners saw only an outerness—something concrete—a fragmentable, hence measurable, experience. Bohm goes on to identify the consequences of this division:

> It is clear that the different ways the two societies have developed fit in with their different attitudes to measure. Thus, in the West, society has mainly emphasized the development of science and technology (dependent on measure) while in the East, the main emphasis has gone to religion and philosophy (which are directed ultimately toward the immeasurable) (p. 23).

Until the late 16th century, Aristotelian *deductive* reasoning dominated the Western view of science. By this time, the time of Francis Bacon, a new perspective had developed. Bacon defined it in an empirical methodology; Descartes gave it a mathematics; and experimenters like Galileo gave it practice and validity (Hampshire, 1956). It is not surprising that by the late 18th century a William Farish would find the measurement of student thought to be appropriate.

A cognitive leap had been made—a deduction made from behavior was as valid as an inductive conclusion developed through empirical scientific inquiry into the physical world. Once this idea became accepted new sciences (e.g., psychology, sociology) could be seen as *scientifically* valid. Borrowing from Massimo Piattelli-Palmarini (1994), I call this type of intellectual leap a *cognitive illusion.* Just as we are capable of sensory illusions, Piattelli-Palmarini and others (Tversky and Kahneman, 1982) found that we are subject to biases and shortcuts in thinking. This combination blinds us, and we ignore the truth that should be the foundation of our decisions. A similar phenomenon occurs with sensory perception.

We are familiar with optical illusions that persist even when the illusion is revealed. The magnificent *Arch*, riverside at St. Louis Missouri, is as wide as it is tall. Yet the illusion consistently persists that it is higher than it is wide. "There is nothing rational in continuing to see the St. Louis arch as higher than it is wide, even when we *know* this is not so. But no one sees it as broader than it is high. The illusion, therefore is . . . neither rational nor capricious. All those who look at the arch are drawn in the same direction (Piattelli-Palmarini, 1994, p. 18).

On a less grand scale, the textbook example where both horizontal bars are of equal length, demonstrates how an illusion persists in the Müller-Lyer illusion (Figure 1.).

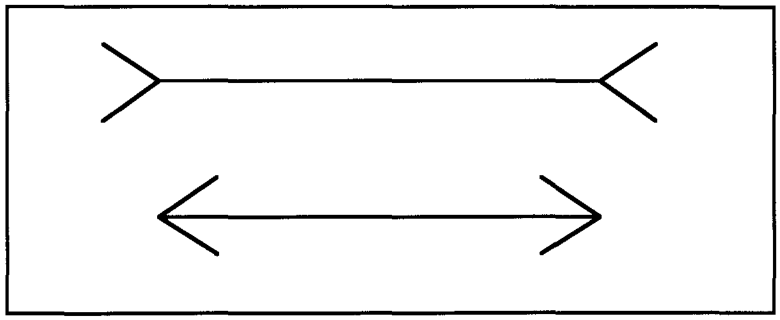

Figure 1 A common optical illusion.

The concept behind these examples of persisting sensory illusion runs parallel to the concept of persistence as it applies to cognitive illusions. In their introduction to *Judgment Under Uncertainty: Heuristics and Biases*, Amos Tversky and Daniel Kahneman (1982) demonstrate a variety of such common illusions. From these I have selected one example that parallels my point that thought can be assigned a value is illusionary. That passage shows that stereotyping in a selection interview is done under illusion. The passage also demonstrates the power of cognitive illusions:

> [P]eople express great confidence in the prediction that a person is a librarian when given a description of his personality which matches the stereotype of librarians, even if the description is scanty, unreliable, or outdated. The unwarranted confidence which is produced by a good fit between the predicted outcome and the input information may be called the illusion of validity. This illusion persists even when the judge is aware of the factors that limit the accuracy of his predictions. It is a common observation that psychologists who conduct selection interviews often experience considerable confidence in their predictions, even when they know of the vast literature that shows selection interviews to be highly fallible. The continued reliance on the clinical interview for selection, despite repeated demonstrations of its inadequacy, amply attests to the strength of this effect (p. 9).

Within the century following William Farish's assignment of a value to thought, the idea that *scientific measurement* could be made to define intelligence as well as thought was given impetus by some of the followers of Charles Darwin and Sigmund Freud. The size of the cranium (Craniology) or the size and location of bumps on the head (Phrenology) were seen as having correlation to and predictors of intelligence. By 1910 Maria Montessori (1913) was lecturing on the intricacies of the science *Pedagogical Anthropology,* where Craniology was a dominant element. The cognitive illusion here was also one in which correlation can be equated with cause.

While Montessori's impact on the early years of a child's education profited from her research, it was the work of Alfred Binet that has had the most far reaching influence—one that extends beyond education.

Binet and IQ

> In October, 1904, the [French] Minister of Public Instruction named a commission which was charged with the study of measures to be taken for insuring the benefits of instruction to defective children. After a number of sittings, . . . [t]hey decided that no child suspected of retardation should be eliminated from the ordinary school and admitted into a special class, without first being subjected to a pedagogical and medical examination from which it could be certified that because of the state of his intelligence, he was unable to profit, in an average measure, from the instruction given in the ordinary schools.
>
> But how the examination of each child should be made, what methods should be followed, what observations taken, what questions asked, what tests devised, how the child should be compared with normal children, the commission felt under no obligation to decide. It was formed to do a work of administration, not a work of science.

> It has seemed to us extremely useful to furnish a guide for future Commissions' examination. Such Commissions should understand from the beginning how to get their bearings. It must be made impossible for those who belong to the Commission to fall into the habit of making haphazard decisions according to impressions which are subjective, and consequently uncontrolled. Such impressions are sometimes good, sometimes bad, and have at all times too much the nature of the arbitrary, of caprice, of indifference (Binet and Simon, 1916/1973, p. 9).

This defines the problem that Alfred Binet (later joined by Théodore Simon) sought to solve in 1904. The original intention was scalar—to give a structure to overcome the arbitrary diagnoses and abuses practiced by fellow psychologists. While the terminology for dividing the degrees of retardation or subnormality into three levels was generally accepted (idiot, imbecile, and moron),[11] judgments of limits made for each were hazy at best.

The experimentation that resulted in the Binet-Simon Scale was essentially completed by Binet's death in 1911. Henry Goddard, the director of the Vineland (NJ) Research Laboratory, used the 1908 scale version in the first American application in 1910 (Goddard, 1916/1973, p. 5). Up to this time the scale was administered individually in a one-on-one verbal question and response format. Lewis Terman of Stanford University developed a version based on the statistical concepts of normal distribution and standard deviation which could be administered to groups—the Stanford-Binet (Gould, 1981/1996, p. 207). In 1917, Robert Yerkes of Harvard, with the assistance of Goddard and Terman and others, developed a three level series of tests for the army based on Terman's work—"... the first mass-produced written tests of intelligence (Gould, pp. 224, 225)."

Binet had defined intelligence in terms of judgment. He would divorce it from the medical and pedagogical reliance on elements traced to biological or acquired knowledge influences. "[I]n intelligence there is a fundamental faculty, the alteration or the lack of which, is of the utmost importance for practical life. This faculty is judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances (Binet and Simon, 1973, p. 42)."

Anticipating misinterpretations of the application of the scale he makes a distinction between what appears to be measured and the practical use—a means of classification:

> This scale properly speaking does not permit the measure of the intelligence, because intellectual qualities are not superposable, and therefore *cannot be measured as linear surfaces are measured*, but [it is] on the contrary, a classification, a hierarchy among diverse intelligences; and *for the necessities of practice this classification is equivalent to a measure*. We shall therefore be able to know, after studying two individuals, if one rises above the other and to how many degrees, if one rises above the average level of other individuals considered as normal, or if he remains below. Understanding the normal progress of intellectual development among normals, we shall be able to determine how many years such an individual is advanced or retarded. In a word we shall be able to determine to what degrees of the scale idiocy, imbecility and moronity correspond (Binet and Simon, 1973, pp. 40-41; emphasis added).

Transplanted from its original purpose—"insuring the benefits of instruction to defective [French] children"—the scale measuring individual developmental differences was translated within a few years into mass measurement of intelligence of Americans. A cognitive illusion morphosis was affected. A valid statistical device—the normal distribution curve—was applied to a situation where the individual was viewed as part of a mass of probability events:

> The only difficulty with the psychologists' reasoning, and an important source of conceptual confusion, was that unlike flipping pennies, the normal distribution curve did not automatically emerge in giving tests of intelligence. The normal distribution curve of intelligence would emerge only if the test was specifically constructed to create the normal distribution. If the test was too difficult, the results would be skewed in one direction; if too easy, the results would be skewed in another direction (Marks, 1981).

Gould points out that the sub tests are helpful in diagnosis. "Speaking personally, I feel that tests of the IQ type were helpful in the proper diagnosis of my own learning-disabled son. His average score, the IQ itself, meant nothing, for it was only an amalgam of some very high and very low scores; but the pattern of low values indicated his areas of deficit (p. 185)." The original intent can be helpful, but its perversion adds mirage to illusion. In the trip across the Atlantic extrapolations of racial inferiority were attached to an already heavily biased concept.

This mirage has a clouding effect that, unfortunately, turns focus from the initial invalidity of the concept. Intellectual energies are dissipated combating a blatant misuse of data. Critics of such works as *The Bell Curve* are wasting their time, ending up preaching to the choir, since the intended audience is listening to the radio talk-show hosts who play loose with truth in their intent on high ratings. The egregious malevolence and disingenuous nature of the motivation behind *The Bell Curve* are evidenced in duplicity of the self effacing preface which reasons:

> To try to come to grips with the nation's problems without understanding the role of intelligence is to see through a glass darkly indeed, to grope with symptoms

> instead of causes, to stumble into supposed remedies that have no chance of working.
>
> We are not indifferent to the ways in which this book, wrongly construed, might do harm. We have worried about them from the day we set to work. But there can be no real progress in solving America's social problems when they are as misperceived as they are today. What good can come of understanding the relationship of intelligence to social structure and public policy? Little good can come without it (Herrnstein and Murray, 1994).

Given the biased racial premise that argues throughout the text there is little room for misperceiving the authors' intent. However, the last two sentences are ironically true within a change of context, making enunciation all the more invidious.

The cognitive illusion that educators hold about testing in general rises from the illusion created around the experience with IQ. The proposition that a set of questions could be so arranged (normed) that they would consistently predict a specific cognitive or behavioral outcome is ingrained in the thinking of educators. In spite of the caveats of test publishers that point out the fallacy of excessively relying on standardized tests for placement,[12] educators rely heavily on such tests for college placement and tracking. This reliance is transferred to an untutored public through the media who use the data as barometers for judging school systems, administrators, and teachers (Botstein, 1997). This is further reinforced by another illusion, widely held especially by politicians—that education can be managed like a business.

THE EMPIRICAL AND THE EFFICIENT

The Business Model

Administrators have a history of responding to the call to run the school like a business by following the lead of business and industry. In the process they impose a series of fads on teachers who in turn develop a cynicism based on the experience that whatever the craze of the moment it will be short-lived. Many saw a variety of business inspired fads as answers to the question of how education could best be achieved (e.g., Demming's quality management (Bonstingl, 1992); but, most were scrambling for a holy grail that would answer the Regan era's monument, *A Nation at Risk (*National Commission, 1983). However, even in cases where adoption of business methods could be efficacious, the adoption is so shallow as to be counter productive.

In addition to having the business community as a source, these fads generally have two characteristics: a catchy buzzword; and a well documented and well-marketed management style. Educators usually translate the business term *management* as *leadership*, giving it a more benign connotation. Whether called management or leadership, administrators are easily *sold* on innovation.

One management innovator is Tom Peters who has created a not too small cult empire around *excellence*. In his third book, *Thriving on Chaos* (Peters, 1987), he manages to cite hundreds of how-to-manage formulas and success stories into around 700 pages of fast paced text. So influential is this book that often candidates for principalships are quizzed on how they would implement the ideas he offers.

Peter's concept of management by walking around (MBWA) requires too much on the part of the administrator. To implement this concept the school's hierarchical structure built over time must be abandoned and, as with the worker in the factory, the teacher brought into the process. A new trust would have to be developed and that would only be a beginning:

> A deeper issue emerges here for the first time . . . . We must fundamentally shift our managerial philosophy from adversarial to cooperative. Protecting functional fiefdoms and hoarding information is the American middle management norm.

> The seemingly straightforward plea in this prescription for cross-functional quality teams peels off but one layer of a big onion (Peters, 1987, p. 94).

The idea of cross-functional quality teamwork (educators read: cross-discipline plus cross-power) embodies merging vertical and horizontal responsibility concepts—the divisive fiefdoms and hoarded fiscal information. To achieve excellence, the lord and the serf—the lion and the lamb—must lay together. That takes trust.

Francis Fukuyama defines trust as: "[T]he expectation that arises within a community of regular, honest, and cooperative behavior, based on commonly shared norms, on the part of other members of that community. Those norms can be about deep "value" questions like the nature of God or justice, but they also encompass secular norms like professional standards and codes of behavior (Fukuyama, 1995, p. 26)."

As usually happens with the faddish, the depth of execution is as shallow as the buzzword itself. And these buzzwords mix themselves into a cacophony of echoes of each other.[13] Adding to the confusion there is the built-in illusion that to be successful there must be no chance of red ink in the bottom line.

In one of the school districts in the tri-county area near Youngstown, Ohio, the president of the school board proudly announced that the board, under his leadership, had amassed one million dollars. "Proven business practices, such as downsizing, had been successfully applied to the system," he exulted. In spite of his position in education he, like most laymen, succumbed to the illusion that education is only about money. Evidently he had selectively read *A Passion for Excellence* (Peters and Austin, 1985), another *must read* for 1980's businessmen and educators going into administration.

Tom Peters points out that ". . . in the school, efficient management of the budget is vital; yet a great school is never characterized by the remark, 'It has a good budget.' The superb school is superb only by virtue of its success in developing its ultimate customer:

the student (p. 5)." The board president is oblivious of the cost of that million dollar hoard to his system in terms of the student who had to suffer the deficiencies of overcrowded classes and demoralized teachers whose pay scale had dropped to the lowest in the county. His cognitive illusion lays in the persistent and naive belief that fiscal responsibility is the equivalence of profitability. Fortunately, not all boards with the illusion that schools can be run as if they were a business are this extreme.

Fukuyama's social culture context of trust is not reflected in the actions of this million dollar board. Their actions betray trust. Loss of trust, exhibited by the interplay between the board's centering on the accumulation of profits and the institution's responsibility to the student, exacerbates adversarial tensions. But this is part of the culture in which SchoolNet is being imposed. Most teachers do not expect *cross-functional quality teamwork* to help them.

Fad management styles and fiscal concepts such as profit and bottom line are the obvious overlays from business and industry. Omnipresent, but less obvious is the heritage of efficiency that burdens both business and education. Profit, bottom line, and success imply efficiency. And efficiency means *scientific management.* This idea is now so ingrained that any possibility of imagining a difference may be lost from the collective memory (Apple, 1993, p. 119).

Scientific Management

Congress passed the Mann-Elkins Act in June 1910 to control rapidly rising freight rates. On November 10, 1910, the names Brandeis and Taylor became household words. At an Interstate Commerce Commission (ICC) hearing on rate increases by several of the country's largest railroads, Louis Brandeis, the opposing chief council, elicited testimony that indicated that the railroads could save a million dollars a day—$300 million a year—if they adopted the Scientific Management methods of Frederick Taylor (Kanigel, 1997 pp. 429-436). Within the space of a few years, the workers in the majority of the manufacturing firms of the world were being *time studied* and teachers in American schools were writing lesson plans.[14]

Defining scientific management (identified variously as the Taylor method or system) is deceptively short and straightforward:

> Scientific management is any management which is based on scientifically ascertained laws and principles, translated effectively into industrial administration. No system alone is scientific management; but scientific management remains a mere disembodied spirit until it becomes incarnate in some system of administration. . . . It must be clearly understood, however, that the Taylor system is not a fixed set of forms and mechanisms, once for all worked out and transferable bodily from plant to plant (Thompson, 1917/1974. pp. 4-5).

It covers all aspects of any organization that uses its tenets. These organizations cover a wide range: factories, the military, publishing houses, department stores, banks, professional societies, and education. In the prototypical model, manufacturing, it controls the product from the ordering, receipt, and storage of raw materials, through the flow of the manufacturing process itself, to the packaging and distribution of the final product; it defines the supervision, skill level, and method of payment for the worker; and, it creates the company's culture and hierarchy from president to sweeper (Thompson, 1974). A culture of efficiency was created where critics would frequently decry the deskilling of workers (Kanigel, 1997) and paved the way for deskilling teachers.

Unlike the fads previously described, the adoption of the scientific management precepts was universal and became ingrained. The idea was not just an echo of the rubric to follow the lead of business: It was a complete surrender to a creed. It was a surrender to an idea that justification for education was economic—not noble, not moral, not intellectual.

This economic model espouses that children are a natural resource that can be exploited to support and improve the common wealth. The means by which this resource could be shaped into a usable product was education. Horace Mann introduced the idea.

In 1842 Mann's vision for the structure of education in Massachusetts was in danger. The State Board of Education and the normal schools, the heart of his vision, were especially vulnerable since they existed at the sufferance of a legislature that was increasingly cost conscious during the 1929-like economic depression of 1839-43 (Vinovskis, 1995 chap. 5). In his *Fifth Annual Report* Mann pragmatically elected to appeal to the "'organ of acquisitiveness (p. 102)'" in his bid for continued funding.

The argument centered on the economic benefits that accrued with added education. Using data, dubious by late 20th century standards, he built a picture of ways the industrialist would benefit from the only real raw material available, its educated children (p. 98). In addition to domestic statistics, he compared the apparent advantages of English manufacturers with the drawbacks in industrial Massachusetts, foreshadowing arguments recently heard in debates over trade in the 20th century. Mari Vinovskis quotes from the *Report*:

> It is a fact of universal notoriety, that the manufacturing population of England, as a class, work for half, or less than half the wages of our own. The cost of machinery there, also, is but about half as much as the cost of the same articles with us; while our capital when loaned, produces nearly double the rate of English interest. Yet, against these grand adverse circumstances, our manufacturers, with a small percentage of tariff successfully compete with English capitalists, in many branches of manufacturing business. No explanation can be given of this extraordinary fact, which does not take into account, the difference of education between the operatives in the two countries (p. 98).

Horace Mann's reaction to his critics took the form of a positive pragmatic strategy. By 1910, when Taylorism burst into public consciousness, administrators lacked the political muscle and moral or intellectual leadership that could stave off even the slightest attack. In *Education and the Cult of Efficiency*, Raymond Callahan quotes the Superintendent of the Denver Schools in 1900, describing an all too familiar state:

> Neither scholarship nor executive ability alone had been found ample for permanent occupation. The school superintendent who, with competent counsel added to his own expert ability, constructs a course of study, condemns the work of a poor teacher, objects to the engagement of inferior talent, frowns upon the purchase of unnecessary apparatus, or, what is even more threatening, recommends the substitution of a better textbook for a poor one, understands full well that, however unanimous may be the support of his board, many taxpayers, as well as mercantile and commercial interests, are sure to take a hand either to forward or prevent the execution of whatever plans he may devise. The inevitable letter to the press, over the anonymous signature of "Taxpayer" is a reminder that the people propose to allow their representatives on the school board to act their will only when it coincides with that of the individual opinion. And so one has a right to assume that, in addition to the power and skill of the superintendent of great industries, the superintendent of schools needs another qualification—that of mollifying and educating a great and not always prudent or well-informed constituency (Callahan, 1965, pp. 52-3).

Scholarship, a prized requirement for leadership in the 19th century, eroded as mollification and public relations became such a dominating focus of administrators by the end of the 20th century that leaders are judged by jocularity[15] rather than learning.

By 1912 Taylorites, like Harrington Emerson (one of Brandeis's witnesses at the 1910 ICC hearing) were prominently lecturing educators on scientific management (p. 55). Universal adoption of the principles shaped all aspects of the school. Seating charts, lesson plans, teacher evaluation, school floor plans, bell schedules, textbook format, cost per pupil, electives: All were imposed in the name of efficiency. Textbooks, for example, were seen as a device to make allowance for poorly trained, even untrained, teachers. Teacher-proofing texts was the beginning of a spiral of deskilling strategies that allowed standardization of the curriculum, culminating in a situation where, ironically, critics could charge national risk because of inefficiency (Apple, 1993). Standardization of the curriculum necessitated standardized assessment. With the expansion of IQ testing by Terman, Goddard, and Yerkes as models, others (e.g. Leonard Ayres and Edward Thorndike) developed widely used, objective standardized tests for everything from handwriting to arithmetic (Callahan, 1962, p. 100).

So strong is the drive for efficiency that some practices defy rationality. Every secondary teacher knows that the first two or three classes of the day differ significantly from those of the rest of the day. The majority of students are uncharacteristically quiescent, almost to the point of lethargy. Some are even nodding off. Research in teen physiology explains the phenomenon. Circadian clocks in teens are wired for a normal wake-up near 9:00 or 9:30. Schools start near 7:30, up to two hours too early. Why do high schools start so early? Two reasons are put forth: "We've always done it that way;" and, the bus schedule—it is more efficient to bus teens early than to move up the elementary schedule a half hour.

The rationale for scientific management is identical to the hypothesis that gives standardized testing its dubious stature: All things are measurable. In a surrealistic symbiosis, scientific management is a pillar supporting standardized testing, which, in turn, is a tool that sustains scientific management. Each involves efficiency and holds that its legitimacy is derived from empirical science. However, to give standardized testing a *raison d'être* there must be something to test.

CURRICULUM AND INSTRUCTION

Education is a body for which the life fluid is *science*. The skeleton, which draws into its sustaining marrow that life fluid, is *efficiency*. The flesh and sinews that gives it form are *curriculum and instruction*. These receive their energy from the life fluid as philosophy. The substance of the flesh and sinew is content and method. As with any body the exterior is the part that gives identity to the whole. Thus it is that when we speak of education it is superficial. We generally speak in terms of the flesh and sinews—curriculum and instruction. The body, education, is acclaimed or damned couched in terms of curriculum and instruction.

Classroom teachers shape their identity through content and their individuality through method. One is not a teacher, but teaches *first grade* or teaches *algebra*. Within the frame of content one teaches *the basics*, or one teaches *the whole child*, or any number of permutations or blendings of methods. The source of content is fixed in the course of study derived from textbooks; the source of method is less clear in that it is based on imitation strongly influenced by earlier school experience in combination with administrative fiat and teacher-training modeling.

For good or bad, those who would form education are not classroom teachers but are drawn from a variety of authorities: politics, and the universities dominate. The philosophies of these two power bases are reflected in content and method. This was not always so.

The Formative Evolution

In the early years in New England, the content received authority from the church and was biased toward reading the *Bible* and a rote and recitation style suited. However, as the society became more complex and the theocracy gave way to the needs of a mercantile economy, a new broader view of education was being perceived by the classroom teacher which went beyond the limiting nature of content in schools as then structured.

> The New Jersey schoolmaster Enoch Cobb Wines, for example, in an extraordinary tract called *Hints on a System of Popular Education*, observed in 1838: "As a nation, we are educated more by contact with each other, by business, by newspapers, magazines, and circulating libraries, by public meetings and conventions, by Lyceums, by speeches in Congress, in the state legislatures, and at political gatherings, and in various other ways, than by direct instructions imparted in the school room." If so much "general intelligence" had already been achieved through those means, Wines continued, what might not be anticipated from the addition of a well-organized and comprehensive system of ordinary schooling (Cremin, 1980, p. 370)?

Wines' idea complemented Horace Mann's plea to give uniformity to schools as well as "a bond of brotherhood and family (p. 155)."

By late in the second decade of the 20^{th} century, this expansion had taken on overtones of social Darwinism, and the schools assumed a sorting function through standardized testing as developed by Lewis Terman (IQ) and Edward Thorndike (achievement) (Cremin, 1988, p. 233). In the process, a new and complex social construct has been imposed on education. Thomas Popkewitz expresses this in terms of struggle between the individual and society. He suggests that historians by employing a heuristic approach to their studies are missing the point of the relationship between the individual and society. He asserts that the study of school itself must be reexamined:

> Too often, the problem of study takes for granted the development of the school as a normal evolution in societies. History is most often that of exemplars, selecting the relevant examples to illustrate the growth of a civilization. The function of the history is didactic, illustrating the traditional pieties or the general and natural laws that underlie human development.
>
> The difficulty of the pieties and laws of development is that they are neither. The 'natural' histories were inventions of those who were able to exercise power in giving moral direction and will to a society. . . . To accept uncritically the histories of school development is to obscure the biases of its social organization of its discourse. . . .
>
> The discourse of schooling ignores the functions assumed by the early 20th century; that of socialization, labor selection and institutional legitimization. It removes from scrutiny the tensions of individual and community. The individual is seen to exist as separate from a social world which contains inequities, differential power arrangements and competing conceptions of knowledge (Popkewitz, 1986, p. 20-21).

This individual versus society dichotomy is expressed mainly through the ways in which the dominant shapers of reform would forge change in content. Some (mostly politicians) appear prepared to dismantle the 20th century *relativist* culture and return to an easily assessed basic core content of a *McGuffey Reader* age (Finn, 1991). Some (mostly academics) see “inequities, differential power arrangements and competing conceptions of knowledge” as challenges to be tamed creatively and democratically—through individuality (Gardner, 1991). Lost in the melee is the classroom teacher.

The community is not of one mind. The vocal seek to poll changes into place. Roused by the deliberate combination of uninformed and misinformed provocations by ratings inspired radio talk-show hosts, Wines' educated populace is suffering a mental prolapsus.

Nowhere is this more visible than in the political analyses of the goals of education. For instance, the recommendations that are part of the *America 2000* strategy include the controversial school vouchers issue. Using Orwellian doublespeak and lost in a cognitive illusion, it also offers a purely voluntary national core curriculum and testing program through which all schools can be compared, resulting in a greater accountability.

A Nation at Risk: The Imperative for Educational Reform (National Commission, 1983) is the prototypical criticism of curriculum and instruction. It muddles legitimate educational issues and does nothing to illuminate the execution of the alternatives it suggests. In addition to the demonstrated misuses and distortions of data (Thornburg, 1991; Berliner and Biddle, 1995), the obfuscation subtly rises from the lack of parallel between the *findings* and the *recommendations*. The former are identified in behavioral terms based on test scores (e.g., pp. 8-9); the latter are put forth in subjective cognitive terms such as "discuss intelligently" (e.g., pp. 25-26). As suggested by David Berliner and Bruce Biddle (1995), it is a *Manufactured Crisis* created to appeal to divisive biases, undermining honest debate.

Appeal to bias makes for headlines and sound bites: "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war (National Commission, 1983, p. 5)." Coming from a federal commission, that declaration is newsworthy because it is inflammatory; coming from this federal commission it is unworthy and duplicitous. Unreported and unheard in the debate that this report engendered is a later line reminiscent of Pogo's declaration that the enemy "is us": "That we have compromised this commitment [to education] is, upon reflection, hardly surprising, given the multitude of often conflicting demands *we* have placed on our Nation's schools and colleges (p. 6, emphasis added)." The *we* are those who control the schools: the full panoply of political entities from the Congress to the local school board and their administrative arms.

The pattern appears to be one of blame shifting. One where the real power centers, political and financial, mask their unwillingness to accept the outcomes of egregious dedication to their "organ of acquisitiveness," masking a more critical "act of war." David Tyack and Larry Cuban (1995) suggest such a scenario:

> It would take no great effort of the imagination to attribute U.S. economic ills to worldwide recession and to mismanagement on the part of business and government. Witness, for example, the effects of burgeoning deficits, deregulation of S&Ls that permitted a few knaves to squander billions of dollars of other people's savings, slowness to upgrade factories or to adopt new strategies of management, or undue attention to the short-term bottom line of profits. It may be convenient to blame the schools for lack of economic competitiveness, but this strategy distorts both educational and economic analysis. Good schools can play an important role in creating a just, prosperous, and democratic society, but they should not be scapegoats and are not panaceas (p. 39).

Shrouded by this humiliating foreground noise, the milieu of the classroom continues to function within the parameters of its perceived mission. At the heart of this is the interpretation of what constitutes the curriculum.

Content

Lawrence Cremin, in his monumental histories (e.g., 1980 and 1988), views the American education experience as coming from a variety of sources beyond formal schooling: Newspapers, magazines, libraries, Chautuaquas, pulpits, parents, and quilting bees were only some of the less formal ways of educating. In spite of a casual quality this education has a structure that some have named the *hidden curriculum*. This unobtrusive source of knowledge dwarfs the *overt curriculum* of the school. Sometimes it is hard to distinguish one from the other: Michael Apple (1991) focuses on the hidden curriculum in the school as expressed through the intrusion of the commercial television news program, *Channel One*. Sometimes a hidden curriculum is seen as imbedded in the overt curriculum: William Kilpatrick (1992) centers on the mixed moral signals in *values clarification*.

These expansions, definitions, and refinements of curriculum are views from those external to the school. If and when present, for good or ill, they are subliminal. Within the teacher's classroom, concentration can only be centered on the overt curriculum. The overt curriculum is embodied in a detailed document, *the course of study*. Each discipline is defined through its course of study and, coupled with a textbook, determines the daily progression and structure of the course itself. It is the embodiment of efficiency, for no item is omitted in the effort to codify the specific learning goals of the subject.

The major dimensions that define student learning are time, the classroom, and content. Each is fragmented during the learning process. The relational fragmentation is expressed functionally: In the elementary classroom, the room remains constant and the content varies over time; in the high school, the content and room vary over time. Even within these structures there is variety. In the elementary classroom, individuals are grouped and regrouped into different spaces within the room as content-time changes. In the high school, class composition changes with content, room, and time.

To the community, the curriculum is the school; to the school administrator, the curriculum is expressed in fragments as subjects; to the classroom teacher, the curriculum is unfolded in content, a series of *facts*. That teacher's identity is received through the institutional structure but the expression of that identity is by *covering* discrete bits of knowledge. It is this incremental, expanding fragmentation, level by level, that creates a formidable babel wherein the most fluent can misconstrue nuance. Into this polyglot, the legislature introduces a new linguistic family by fiat.

Fragmentation is not a phenomenon unique to education broadly or to the classroom specifically. It is a reflection of a more universal principle. It would appear on the surface that fragmentation is natural. David Bohm (1980) describes the complexity:

> [A]rt, science, technology, and human work in general, are divided up into specialties, each considered to be separate in essence from the others. . . . [and] . . . men have set up further interdisciplinary subjects, which were intended to unite these specialties, but these . . . have ultimately served mainly to add further separate fragments. . . . [and] . . . society . . . is broken up into separate nations and different religious, political, economic, racial groups, etc. Man's natural environment has correspondingly been seen as an aggregate of separately existent parts, to be exploited by different groups of people (p. 1).

Bohm develops the argument further as he indicates that fragmentation is the consequence of man's attempt to ". . . reduce his problems to manageable proportions (p. 2)." However, he points out that this penchant for seeing the fragments existing only as separate units is an illusion.

The Trumbull County (OH) *Course of Study in Language Arts* identifies some 190 discrete objectives[16] for the ninth grade in literature, grammar, reading, and composition. The whole is given shape by an efficiency expert inspired flow chart. In the chart (Figure 2.) the lowest level is fragmented into aspects of the level above, resulting in a combinatorial explosion. In this situation we see the ludicrous consequences of fragmentation. The situation becomes even more surreal when placed in context: English teachers formed the committee that proudly and cooperatively produced this document.

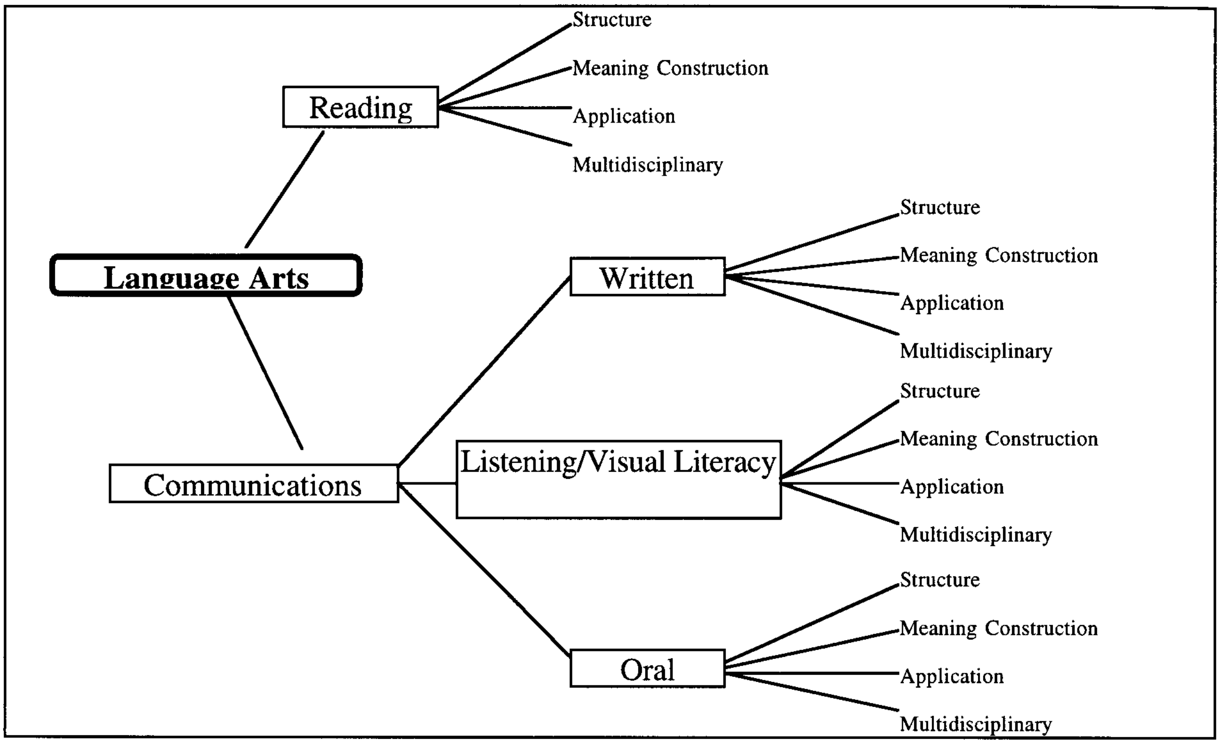

Figure 2 A Language Arts web.

Because the tendency to accept the separateness persists in spite of the knowledge of the relationship to the whole, I suggest that teachers experience it within a cognitive illusion. In the classroom, the teacher will insist that she sees the whole and she conscientiously communicates this to her students. My experience informs me that the course of study through my lesson plan dictates my concentration only on the part, and does not allow me to go beyond that except superficially. The teachers' cognitive illusion becomes the students' reality. The student experiences fragments as wholes and cannot make sense of them. Fragments are their reality.

Hidden behind and mixed within this discussion of content and fragmentation is another factor that cannot be separated from either. Like the strands of the DNA double helix, content and method cannot exist alone. One cannot be described without the other; they encroach upon each other; they complement each other in the mathematics sense.

Method

The most personal and individual part of the educative experience is reflected in how the teacher organizes and presents the content. The method the teacher uses is the interface between teacher and student. The approach is supposed to reflect the teacher's philosophy. Sometimes a cognitive illusion intercepts and the method employed fails to approximate the method avowed. While not singular to the teaching of mathematics, a recent and unusual study demonstrates the phenomenon.

James Stigler of UCLA conducted a three nation study in which he videotaped mathematics teachers in eighth grade classes[17] (Lawton, 1997). The procedures used in any of the classes could easily be drawn from any American methods textbook from the past twenty or thirty years. The contrasts in classroom structure and uses of time may or may not rise from cultural differences. That is not the point here; the cognitive illusion is. As the tapes demonstrate—more than lesson plans can, more than mission statements can—how a method and an avowed practice can be asynchronous. Lawton summarizes this effect in her report on the research:

> [T]eachers in Japan typically have students begin with an unfamiliar problem. The children wrestle with it individually, without help from the teacher, then troop to the blackboard to offer different ways of solving it.
>
> The time when students try to work out a new problem on their own is routine in Japan and even has its own term, *jiriki kaiketsu*: to solve under one's own power.

In the United States and Germany, teachers typically show how to solve an example problem, then the students practice solving similar problems while the teacher helps those who are having difficulty

One of the most striking things about watching the videotapes is how actively the Japanese students participate in presenting varied, but equally acceptable, versions of solving the same problem.

The German and American students spent portions of their class time collectively sharing the homework they'd already done, while Japanese students rarely did so. And only American students, the study found, spent time in class actually working on the next day's homework.

When the researchers looked at the mathematical concepts presented in a lesson, they found similarities between Germany and Japan, and significant differences between those two countries and the United States.

For example, more than three-quarters of German and Japanese teachers took time to explain a concept such as the Pythagorean theorem, rather than simply stating it. Fewer than 20 percent of American teachers did so.

According to the questionnaires, U.S. teachers thought they were implementing the latest reform thinking on math instruction, notably the standards issued in 1989 by the National Council of Teachers of Mathematics. Those voluntary standards are considered a model for national reform.

Asked to evaluate the lesson they taught, almost three out of four of the American teachers who were taped said it was reasonably in accord with current ideas about the teaching and learning of math.

> But when Japanese students solve problems, generate alternate solution methods, and explain their thinking, they're often closer to American reform than many Americans are (p. 23).

This cognitive illusion is not the sole factor that can affect method. In spite of the sincere efforts of reformers to change method, there are two other constrictions within the classroom culture that defeat any concept of mission whether inspired by reform or retrenchment. Both have been observed in other contexts. One is derived from associative psychology; the other is a product of scientific management.

The first determiner of the shape of method rises from the concept S→R. The experiments Skinner conducted were on animals. He proved that, given a stimulus (S) often enough, the animal will respond (R) in a manner determined by the individual orchestrating the stimulus. The response must always be in behavioral terms. This works very well with animals. It is one thing to control animal behavior; it is something else to control human behavior. When applied to humans, the S→R exchange becomes a short circuiting device. Instead of being a technique for enhancing student understanding, it fosters behaviors that *appear* to be learning. Applied to the classroom S→R yields rote learning. Carried to extreme, the orchestrator of human behavior can and did produce brainwashed prisoner-of-war zombies prepared to denounce their families, comrades, country, and religious beliefs.

Rote learning differs from rote memorization. Memorizing the multiplication tables saves a great deal of time in mathematics, and thus is of advantage. The failure in learning occurs when the multiplication tables or the definition of multiplication itself becomes the thing to be learned. If the student has not internalized the commutative property of addition that underlies multiplication, the student has not learned multiplication. In this situation, teacher tests, recitations, and other assessment devices will result in high grades but not learning.

Most of us can tell when a number is odd or even; all of my BASIC programming students can. They can, that is, until they have the problem that reads: Write a program that will accept an integer and print it, if it is even. With rare exceptions, my students have no idea how to solve the problem—the problem of how to program for odd or even. They had memorized the single digit sets of odd and even numbers. In or of itself that is not a bad idea. It provides a handy tool to identify a large number as odd or even without going through the division. However, they had not learned—internalized—the concept that a number divided by two is even if there is no remainder. Eventually they do program using n/2=INT(n/2), but not before I walk them through the odd-even concept.

The method that works best at the level of rote learning is programmed learning. It works because it is behavioral in conception and execution. Tests that use multiple choice, matching, word choice, or fill-in-the-blank are also behavioral, and reinforce rote learning by teaching it. Knowing that a test will be given in this general format imposes the best strategy—memorizing keywords. In the end the teacher has a grade. But what does the grade mean? Has the student been tested on a concept or on a strategy? This problem is compounded when the answer sheet is processed by computer.

The motivation behind writing one of my first programs, a grade book, was to eliminate the rush and waste of time averaging grades on the calculator every six weeks. Over time the coding filled a thick notebook as feature after feature was added and I advanced from a 4K Ohio Scientific with cassette storage to a 48K Apple II+ with a floppy drive. To eliminate another headache—grading the weekly vocabulary quizzes in my English classes—I purchased a card reader and rewrote the manufacturer's program to conform to my grade book adding a program module to record the results for me. Now I could give a test, score it, have the scores recorded and not have to bother with the mechanics of the process or see another vocabulary quiz.

This was a mistake. I lost track of what the students were doing in vocabulary. I had no idea about the kinds of errors that students were making. I had none of the feedback that a test gives to a teacher; none of the information necessary to correct course when something is not right. The card reader now rests as an artifact on the bottom shelf of the glass case that is my classroom museum—a curiosity for my students to ponder; a warning that technology can have unexpected consequences.

The S→R cycle need not be thought of only in terms of students. The standardized behavioral-design test shapes teacher behaviors. Given the pressure that was in play in the Stratfield incident, it is unreasonable to believe that teachers are not teaching-to-the-test. While this can be considered a content related modulator, it does affect method in that the teacher must rely entirely on rote oriented modes.

The second determiner to shape teaching method is subject content. An orchestra teacher-director will approach her classes in ways that differ widely from the ways that an English teacher will approach his. Both, however will be constrained by this factor—content; both will submit a document of method, the weekly lesson plan, covering the activities for each day. The practice has become so ensconced that to not prepare a one is looked upon as an act of insubordination. In this sense the lesson plan is a symbol of domination. A control device that sends the message of mistrust

Scientific management theory suggests that the worker is so incapable of doing anything on his own that he needs a step by step guide to carry him through his duties. So it is with the teacher. It is not enough that the textbook and the course of study have deskilled her in relationship to content. She needs a formulated plan that regulates the structure of the presentation of that content. No matter her philosophy, she will teach by-the-numbers. John Dewey by-the-numbers is as debilitating as Madeline Hunter by-the-numbers.

The most frequently espoused rationale for their continued use implies that lesson plans serve to focus the teacher on the lesson sequence. It is a reminder of where the teacher was yesterday and where he will be tomorrow. If the teacher should be absent, it will serve as a communication between the teacher and the substitute, maintaining continuity. In practice, they are followed by list makers who need to check things off, they are out of date for others who cannot predict the dynamics of the lesson, and they are ignored by the rest—including substitutes who are usually out of their licensed area. Of all things not worth doing well because they are not worth doing, the lesson plan must be at the highest level.

SUMMARY

The classroom milieu into which *SchoolNet* technology is being placed is one driven by science in the form of behavioral psychology and scientific management where curriculum and instruction have been so structured that teachers are deskilled and students are viewed as resources. Increasing reports of ethical lapses in the form of cheating by students and administrators reflect the unnecessary pressures that the sorting and accountability use for which *scientific* (empirical) testing has been devised and applied.

This test dominated culture relies on a cognitive illusion that all things can be measured, leading to distortions such as the belief that grades reflect learning or distortions such as found in *The Bell Curve* and *A Nation at Risk.* Compounding these distortions is the fragmentation of the curriculum. This fragmentation is nominally viewed as a whole, but in practice is treated in discrete units. All of these contribute to a misinterpretation of the purpose and function of the school.

CHAPTER 3—SOFT GEOMETRY

INTRODUCTION

In the period from just before W.W.II to the present, two new ways of understanding in the sciences have evolved. One common characteristic of each is reflected in how these systems approach their disciplines. Instead of the conventional linear and niche approaches found in a traditional science like physics or chemistry, these scientists look across disciplines in their search for understanding. The oldest, *cognitive science*, embraces psychology, artificial intelligence, neuroscience, anthropology, linguistics, and philosophy (Gardner, 1985). The youngest science, *the science of complexity*, officially dates from 1987 (Waldrop, 1992) and draws from cognitive science and physics, bio-chemistry, economics, social science, and mathematics (to identify only one layer of expertise)

These multidiscipline approaches are conscious attempts to answer the same questions that bothered thinkers like Thales and Aristotle, and, Loa Tse and Confucius some five centuries before Christ. Questions about life, the mind, and nature. Questions, for which answers appear to be global rather than local.

To reconcile the tension between the school culture and the expectations of the legislature, it is necessary to meld ideas taken from the new sciences with more traditional ideas. In doing so I will step out of the fragmented bi-direction Cartesian grid and into a three-dimensional representation. As a bi-product of this process, I hope to model a way of domesticating fragmentation that can reconcile the classroom culture with the technology.

The technique that I wish to build with is somewhere between the rarefied plateaus of logic and the sometimes deceptive crags of rationality. In it, I will be employing a method that I ask my students to use when programming. Sherry Turkle (1995) calls it *bricolage*—tinkering. In this construction I am seriously trying to demonstrate tinkering as a tool for thinking about ideas. If I am successful, I will have presented the process, explained cognitive illusion, and provided my mental model of *Education*.

MENTAL MODELS

Book VII of Plato's *Republic*, begins with the allegory of the cave, one of the most visited parables in Western thinking. It opens with a rather frightening premise:

> See human beings as though they were in an underground cave like dwelling with its entrance, a long one, open to the light across the whole width of the cave. They are in it from childhood with their legs and necks in bonds so that they are fixed, seeing only in front of them, unable because of the bond to turn their heads all the way around. Their light is from a fire burning far above and behind them. Between the fire and the prisoners there is a road above, along which see a wall, built like the partitions puppet-handlers set in front of the human beings and over which they show the puppets (Plato, 1991, p. 193).

Shadows of real objects move across the cave wall, projected by the fire. Sounds that appear to come from these shadows give them the semblance of life, but the sounds are only echoes projected from behind the puppet-handler's wall. These sounds and shadows are the only reality for the prisoners. Each prisoner constructs his own view of the world from his position in the row of prisoners.

The classroom teacher can be said to be in a similar, albeit less stressful, situation in that she receives her sense of self as a teacher through her position in the institution. It is a unique, internal creation, and includes influences from other teachers in the institution and the institution itself. For the others the perspective differs somewhat. It is a similar image but not the same. These self images are made with broad strokes—generalizations and theories. It is an extremely powerful force in how the teachers interact within their culture.

Peter Senge (1990) who calls such images *mental models* suggests that we have always been aware of them through philosophy and literature. In addition to the parable of the cave, classic stories such as *The Emperor's New Clothes* demonstrate how aware cultures have been of that power. He elaborates on the effect when asking:

> Why are mental models so powerful in affecting what we *do*? In part, because they affect what we *see*. Two people with different mental models can observe the same event and describe it differently, because they've looked at different details. When you and I walk into a crowded party, we both take in the same basic sensory data, but we pick out different faces. As psychologists say, we observe selectively. This is no less true for supposedly "objective" observers such as scientists than for people in general (p. 175).

The broad strokes with which a mental model is constructed are a consequence of the way humans think. Lev Vygotsky (1934/1962) posits that the structure of thought originates through the structure of word meaning. He says, "A word does not refer to a single object but a group or to a class of objects. Each word is therefore a generalization (p. 5)."

This understanding of thought differs markedly from the view held by associative psychologists. They hold that thought is speech without sound: That thought can be broken down—atomized—into its elements. Vygotsky says that this line of exploration:

> . . . may be compared to the chemical analysis of water into hydrogen and oxygen, neither of which possesses the properties of the whole and each of which possesses properties not present in the whole. The student applying this method in looking for the explanation of some property of water—why it extinguishes fire, for example—will find to his surprise that hydrogen burns and oxygen sustains fire. These discoveries will not help him much in solving the problem. Psychology winds up

> in the same kind of dead end when it analyzes verbal thought into its components, thought and word, and studies them in isolation from each other. In the course of analysis, the original properties of verbal thought have disappeared (p. 3).

Vygotsky's understanding of the generalization of word meaning can be extrapolated and imposed onto the mental model, shaping it into a generalized construct made through thought. By extension these constructs can make other constructs or theories.

Communication of a mental model is made orally or through action. Some individuals go beyond the verbal and interpret certain experiences based on an internal metaphorical imagery. In his childhood, Seymour Papert (1980) practiced mental bricolage using a mental model of gears. He describes the experience and its effect on his learning:

> I became adept at turning wheels in my head and at making chains of cause and effect: "This one turns this way so that must turn that way so . . ." I found particular pleasure in such systems as the differential gear, which does not follow a simple linear chain of causality since the motion in the transmission shaft can be distributed in many different ways to the two wheels depending on what resistance they encounter. I remember quite vividly my excitement at discovering that a system could be lawful and completely comprehensible without being rigidly deterministic.
>
> I believe that working with differentials did more for my mathematical development than anything I was taught in elementary school. Gears, serving as models, carried many otherwise abstract ideas into my head. I clearly remember two examples from school math. I saw multiplication tables as gears, and my first brush with equations in two variables (e.g., $3x + 4y = 10$) immediately evoked the differential. By the time I had made a mental gear model of the relation between x

and *y*, figuring how many teeth each gear needed, the equation had become a comfortable friend (pp. vi-vii).

I have made three assumptions that are indispensable to my own mental model and my form of bricolage: mental models are unique, mental models are made up of word meanings (generalizations) and theories; and, explications of mental models can be communicated through visual metaphors. Unlike Papert, my inner imaging is not spontaneous. It is usually triggered by building on the thoughts of others. The formation of a meaningful personal metaphor was solved a few years ago when I discovered Edwin Abbot's science fiction satire *Flatland* (Abbot, 1884/1952). Since then I have been able to think without being limited to the linear logic of Cartesian mind and body bifurcation which influences so much of traditional thinking. I call it soft geometry.

In an attempt to show how to overcome the difficulties in visualizing a fourth dimension, Abbot asks the readers to think as if they were in the two-dimensional world of a sheet of paper. After defining the limitations of beings in such a world (e.g., triangles, squares, circles), he projects how they would perceive inhabitants of a three-dimensional world (e.g., cubes, spheres). To aid in making the initial adjustment to Flatland, he proposes that the Spaceland-reader:

> Place a penny on the middle of one of your tables in Space; and leaning over it, look down upon it. It will appear a circle.
>
> But now, drawing back to the edge of the table, gradually lower your eye (thus bringing yourself more and more into the condition of the inhabitants of Flatland), and you will find the penny becoming more and more oval to your view; and at last when you have placed your eye exactly on the edge of the table (so that you are, as it were, actually a Flatlander) the penny will then have ceased to appear oval at all, and will have become, so far as you can see, a straight line (p. 4).

The epiphany for me was that, where I had been seeing only lines, I should have been seeing circles or ovals. Lines were hiding more interesting ways of understanding. By the end of the book I was committed to three dimensions as a device for viewing the world—especially for understanding self organizing systems.

THE COGNITIVE ILLUSION SHIFT

One reoccurring theme in Shakespeare's plays is that of reality versus illusion. It is found in all of his plays but dominates tragedies like *Hamlet*, *Macbeth*, and *Othello*. Awareness of the theme adds depth to the understanding of the plays, but it is not an easy abstraction to get across. When I taught *Othello*, for example, I would try to represent reality and illusion as opposite ends of a continuum. In this model the implication was that somewhere around the mid-point the two merge and somehow the thinking and emotion of the characters becomes clouded, giving a kind of credence to the action. It is important for student understanding of Shakespeare's plots that such a merging is possible or at least explainable. It was my point that that merging is the motivation or cause of Othello's jealousy. I was never satisfied with the model. I was imitating the way the situation was explained to me by my teachers.

More recently I have had to wrestle with student understanding of virtual reality (Rheingold, 1991). This is an experience in which one or a combination of the senses is (are) addressed to mislead a subject into believing that the experience is real when, in fact, it is not. The continuum model, with reality at one end and illusion at the other, seemed to fit. However, to me the mid-point merge is not quite what happens in virtual reality. Superficially there is a merging of reality and illusion, but the experience is more profound. The subject does experience sensual feeling, for example. If the continuum model is unsatisfactory describing the effect of Iago's words in tricking Othello's mind, it is certainly ineffectual in explaining virtual reality. As a prototype model it is flawed.

Viewing the model as a class it is easy to see that the mid-point is the obstacle. The extremes cannot merge. To do so in a true merge results in an oxymoron. By definition these continuum end-points are polar—male/female, love/hate, +/- (Figure 3.).

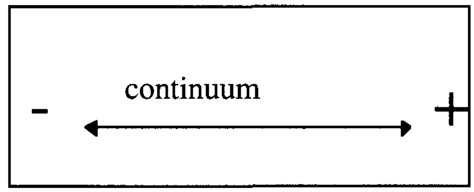

Figure 3. The polarity of a continuum.

The most obvious relational quality they have can be characterized as one in which they mirror each other. If the viewing pattern for the penny that Abbot suggested is reversed (starting from Flatland and moving into Spaceland), the end-points could be lines when viewed from above (Figure 4.). Because they mirror each other the two lines are parallel, reinforcing the intuition that they cannot merge.

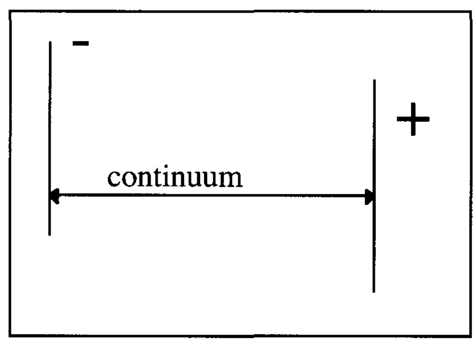

Figure 4. An altered view of a continuum.

Emotions such as love and hate, or experiences such as reality and illusion are not one-dimensional points. Lines, with length only, are also inadequate. To be closer to a proper representation of opposites, they must be represented as planes having two measurements or dimensions. These appear to be of indeterminate length and width, since the concepts themselves are abstract and cannot be measured. Being only ideas they should have no body and should be seen as transparent.[18]

The continuum line is another factor that interferes with comprehension. Continuum connotes time. While change does occur over time, a more pertinent relationship is context. Within the frame of context, the length of the plane can be understood as a function of time—*duration*, and the width of the plane expresses the *intensity* of the emotion or experience. In *Othello* the context for reality and illusion would be the play itself; the context for Othello's love and hate exchange would be jealousy.

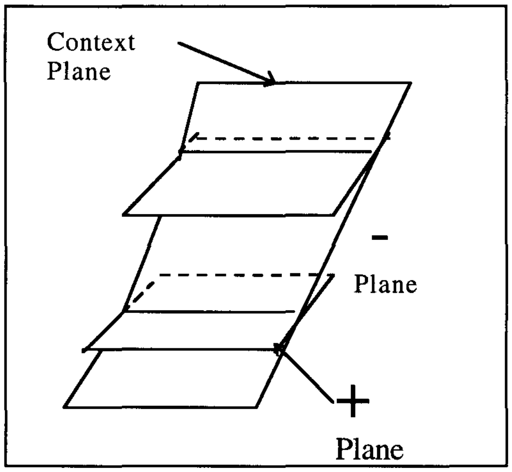

Figure 5. A continuum interpreted using planes.

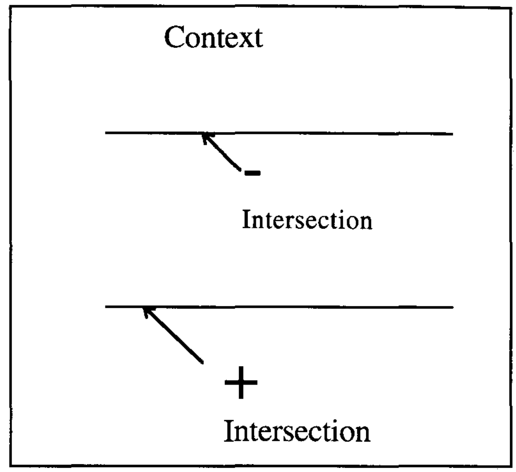

Figure 6. Vertical view

Eliminating the linear continuum in the new model allows a plane, *context*, to be introduced, passing through the parallel planes. Figure 5. shows this in Spaceland or horizontal view. Returning to Flatland in Figure 6., a plan view shows the intersections of the planes as lines. These Flatland lines will soon show us what occurs in a cognitive illusion.

Once the system is established, it tries to maintain an equilibrium. However, a tension exists within the system. That tension originates from the intensity dimensions of the extremes. In the context of education and when reality and illusion are being examined, a strong intensity dimension (*persistence*) in reality will normally maintain a wide Flatland separation between the lines of reality and illusion as happens in Figure 5. However, if the intensity dimension of the reality plane is weak or matches the intensity (*persistence*) of illusion (Figure 7.), the intersections will appear to align. In Flatland, reality cannot be distinguished from illusion as in Figure 8.

While playing around with this representation, I ran into blind alleys that the explanation above now avoids. At one point for example, I visualized what I now have as planes to be shallow box-like structures, having a third dimension that I called *substance*.

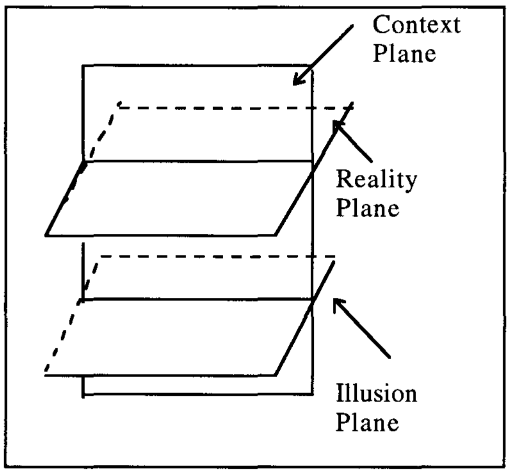

Figure 7. Aligned intersections.

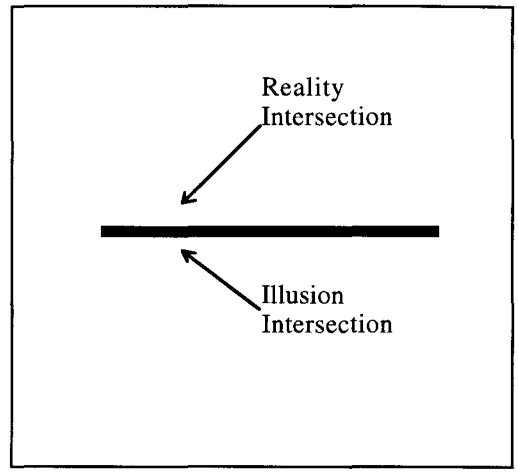

Figure 8. Vertical view.

This complication leads nowhere in interpreting the obscuring effect occasioned by the persistence of illusion. Such unnecessary fragmentation is a siren song, diverting purpose. In bricolage, however, chances can be taken. Tinkering with ideas is pragmatism in action.

EDUCATION AND TECHNOLOGY

In chapter one, Larry Cuban was quoted pointing out three concerns which he calls biases that must be addressed:

- beliefs about the nature of teaching,
- conflicting purposes of schooling, and
- an uncritical embrace of every technical enhancement

The questions implied here echo the purpose of this paper. They should be answered. Framed as they are, however, they suggest their own answer. Cuban's own bias places the focus on ". . . technology-minded reformers . . .," falling into the same trap that other reformers and commentators succumb to when wrestling with education in general or with late 20^{th} century technology in particular.

Some reformers center their attention narrowly on curricular issues, some narrowly on instructional issues, and some narrowly on other reformers. Their illusion is that fragments can be separated from the whole for examination and improvement, expecting the altered parts to reinsert smoothly. Their thinking rises from the empirical belief that all systems are organized and are controlled through a hierarchy. This thinking also gives rise to the variety of conspiracy theories of the kind that would have a handful of Machiavellian industrialists gathered periodically in a smoke filled room, plotting how best to exploit education. The idea of hierarchy has some validity from the reformers perspective at the micro level: States create schools; school boards control local systems; and administrators supervise buildings. At the macro level, however, education demonstrates the characteristics of a self-organizing system.

Self-organizing Systems

Between classes one day about ten years ago, three students rushed into my classroom. They wanted to try an experiment on one of the computers. Mr. Shellenbarger, their statistics instructor, had given them a formula that would produce a way of representing random events that did not follow the standard bell curve of probability—a Mandelbrot set. They wanted to write a program that would use the formula to draw the set. It took twenty-four hours on the Apple IIgs for the program to run its course. For weeks they tinkered with a new geometry, debated chaos theory (Gleick, 1987), the stock market, and fractals. Sometimes three computers would be running day and night exploring some point of contention.

These students were investigating phenomena that the scientific community mainly ignored: the data found in between the science disciplines themselves and daily living; the data found in the organization of a leaf, economic fluctuations, weather, earthquakes, social upheavals, and the shape of the universe. There seem to be similar patterns that occur, repeating at scalar levels. These data seem to suggest order where none should exist—certainly something was observed that acted in a nonlinear sense. All of this seems to occur in patterns without cause. Events occurred in observable (if not always quantifiable) patterns without organization.

In the roughly thirty years since Mandelbrot was able to demonstrate some of the data in his fractal geometry, much has been done to advance understanding of chaos. A newer science of *complexity* explores the phenomena from a wider multi-disciplinary perspective, going beyond the limits of chaos theory. It seeks to understand systems between order and chaos: self organizing systems at the "edge of chaos" (Waldrop, 1992). The dynamics of the evolution of life, economics, civilizations, and revolutions, for example, all seem to follow the same (as yet undefined) laws. The computer program models designed to increase understanding or explain these disparate phenomena are designed as learning systems: systems outside the control of the programmer. As a social construct, Education easily falls within the parameters of such a self organizing complex system.

In *Turtles, Termites, and Traffic Jams*, Mitchel Resnick describes his explorations that seek to explain how organizing events occur through parallel processing models. He demonstrates how the illusion of organization blinds us when trying to understand how self organizing systems operate. He uses the flight of birds to demonstrate the point:

> A flock of birds sweeps across the sky. Like a well-choreographed dance troupe, the birds veer to the left in unison. Then, suddenly, they all dart to the right and swoop down toward the ground. Each movement seems perfectly coordinated.

> The flock as a whole is as graceful—maybe more graceful—than any of the birds within it.
>
> How do birds keep their movements so orderly, so synchronized? Most people assume that birds play a game of follow-the-leader: the bird at the front of the flock leads, and the others follow. But that's not so. In fact, most bird flocks don't have leaders at all. There is no special "leader bird." Rather, the flock is an example of what some people call "self-organization." Each bird in the flock follows a set of simple rules, reacting to the movements of the birds nearby it. Orderly flock patterns arise from these simple, local interactions. None of the birds has a sense of the overall flock pattern. The bird in front is not a leader in any meaningful sense—it just happens to end up there. The flock is organized without an organizer, coordinated without a coordinator (Resnick, 1994, p. 3).

The many *facets of education* can be likened to the individuals in the flock of birds. Like the individuals of the flock, each facet has its own intelligence, instinct, or needs. Like the individuals of the flock, the facets have a general vision or goal. Like the individuals of the flock, each facet senses its position but is not controlled by one entity.

With the idea of self organization in mind, I will again turn to my soft geometry and construct a three-dimensional model that establishes the limits, tensions, and influences that define these facets.

THE TETRAHEDRON INSIDE THE SPHERE

Brainstorming is a method that most English teachers find helpful as an initial step for students who need stimulation in thinking. The technique uses the natural tendency for associative fragmentation as the easiest method of access to a focal topic. In one form of the process a random-topic chart is first created. Related items are then given priority and connected, creating a web-like structure. Other topics that suggest themselves are added to form levels of webs. The process can end at any stage of complexity. One result looks something like Figure 9. Here the complexity is taken to three and four levels. In the course of tinkering, the central or primary focus concept started with the student and moved through some of the other concepts that are at the second level.

Linear linkages imply feedback relationships in this chart. The weight of linkage does not necessarily correlate to the strength of feedback. Nor can it be assumed

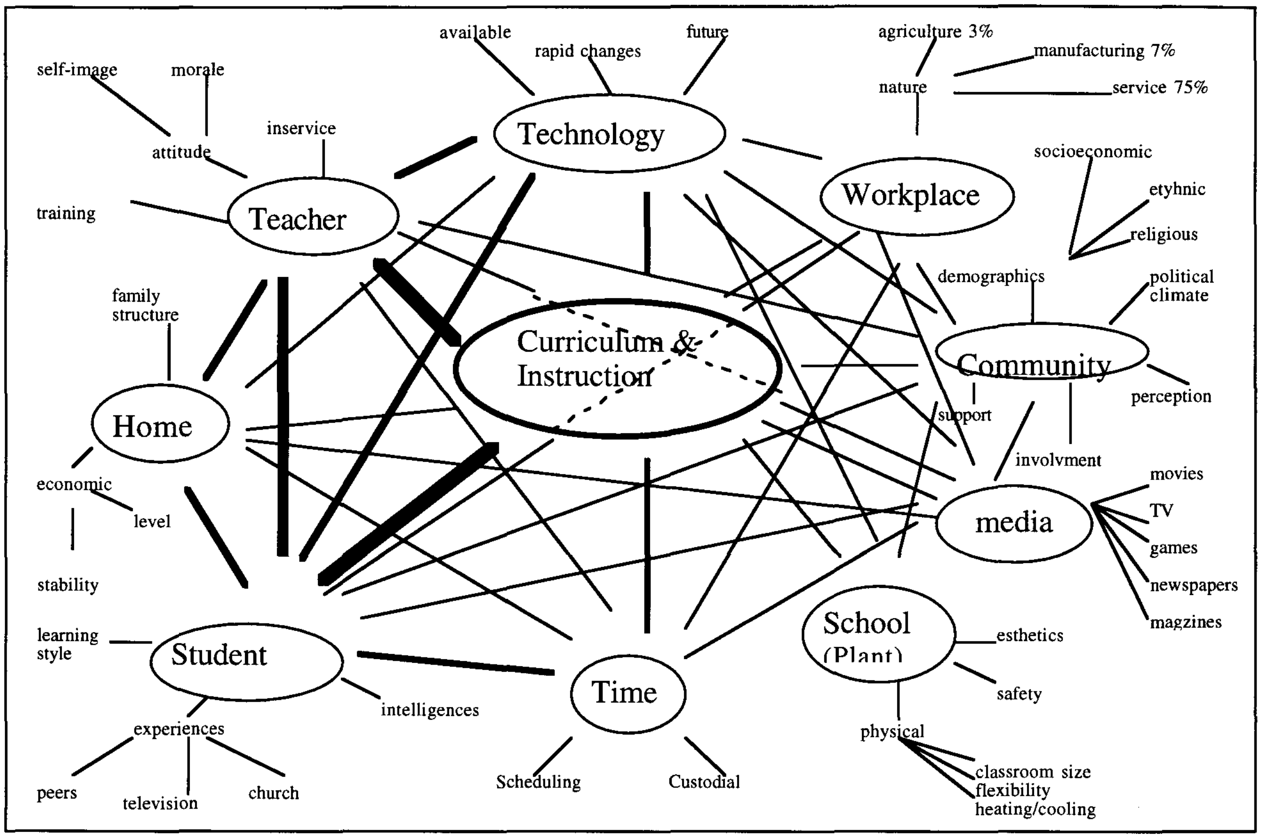

Figure 9. Brainstorming

that feedback has equal intensity in both directions. As other connections are explored their significance becomes arguable because of relative jurisdictional fluctuations.

Figure 9. is not exhaustive by any means. Teachers' unions do not appear, for example. Their exclusion and the exclusion of other entities is not intentional. Even in their absence

they point up the complexity of the interconnecting relationships. The unions' affect on the classroom or in the community cannot be discounted by omission from all discussion.

The initial object in this exercise was to answer the question: In a broad sense, what does Education include? In this chart, *Curriculum & Instruction* was the final choice for the central place because it is the primary tool or driving engine for the institution. Remembering that this is a bricolage exercise, relationships are to be considered as tentative.[19] Weighted lines indicate possible secondary associations: The student, teacher, curriculum and instruction triad is more significant than their associations with home, time, and technology. The significance of the initial triad forms the primary bias of this paper and will not be considered tentative.

Whatever way the webs are arranged at least one pattern can be discerned. This example organizes around four major and interdependent *facets* defining the institution.[20]

- *classroom*—e.g., student, teacher, curriculum and instruction;
- *milieu*—e.g., family, community, media;
- *training*—e.g., academics, teachers, administrators, board members; and,
- *feedback*—e.g., assessment, accountability.

The four facets are not to be considered as static entities. They are composed of self-organizing systems in their own right, each embedded within a larger system. The label classroom (the focus of this paper), for instance, refers to more than an architectural cell within the school building. It includes the complex relationship between the student, teacher, and the how-why-what of curriculum and instruction. In addition, each of these relationships is self-organizing. The student is a complex system that is affected by networks of elements such as the hidden curriculum, peer pressure, and *intelligences* that have multiple manifestations (Gardner, 1983) and that have and identifiable emotional component (Goleman, 1994). These layered relationships are not too unlike the flock of birds: There is organization but not control.

The organizational resonances or interactions of the facets manifest themselves in three ways:

- *limit*—each defines the other three;
- *impact*—each influences the actions of the others;
- *tension*—each contributes to the dynamics of change, locally and globally.

The Sphere of Education

Imagine a blank globe with *the four corners of the earth* marked. (These are quasi-mythical points that are equidistant from each other.) By connecting these points, a map of four regions is created. Each is equal in area, perimeter, and sovereignty. The whole sphere is *Education*. Each region represents the four facets: classroom, milieu, training, and feedback. They are four states united in a one global nation. This Sphere of Education is my mental model of education *idealized*. It is one molecule in society's molecular soup.

If examined closely, the borders of one region coincides with the other three. These borders define or *limit* the other regions. As with political frontiers in a real world, it is not easy to see where one state ends and another begins. Traveling from Ohio into Pennsylvania, chuckhole depth may be the only indication of jurisdictional separation.

In a similar manner, it is not always easy to distinguish role separation between one region to another. The agents of one region *impact* on the agents of another (e.g., agents of the political Milieu determine teacher Training).

As a nation holds a singular vision, the collective regions of Education subscribe to a common purpose. In the manner that stresses develop normally between states in the interpretation of the common vision, pressures grow between the facets of Education. *Tension* can occur locally within a facet or globally between the facets. In complex systems equilibrium is not possible (Waldrop, p. 147). Equilibrium can be likened to a state of entropy. Normal tension is desirable (e.g., curriculum change); excessive tension is enervating (e.g., one-way accountability demanded by the state).

The Paradox Tetrahedron

Imagine that the globe that we have examined can collapse like a balloon. As it looses shape, however, the four corners remain in their relative positions and the borders become the defining edges of a new form. By collapsing the globe, the four facets stand out in sharper contrast, allowing for a clearer visual demarcation between jurisdictions. The borders or limits were on the globe too but now they are less amorphous. This tetrahedron (Figure 10.) is my mental model of the *reality* of education.

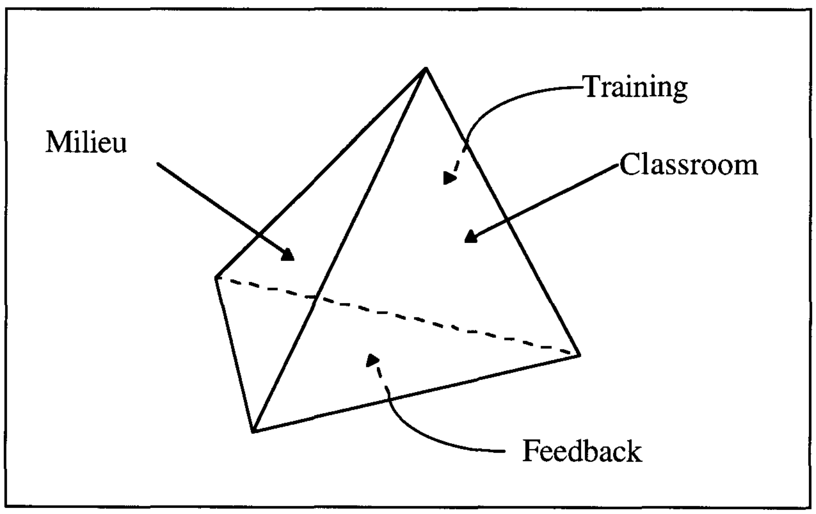

Figure 10. The education tetrahedron.

Through this shape it is easier to understand why it is so difficult for individuals to embrace the totality of Education when trying to adapt to changes imposed by the wider society. As a teacher, for example, it is impossible to see any other facet than the classroom as a total unit (Figure 11.). To attempt to relate Classroom to Milieu the perspective distorts both (Figure 12.).

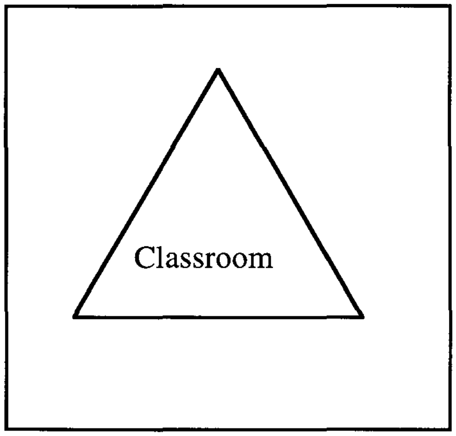

Figure 11 The facet, Classroom.

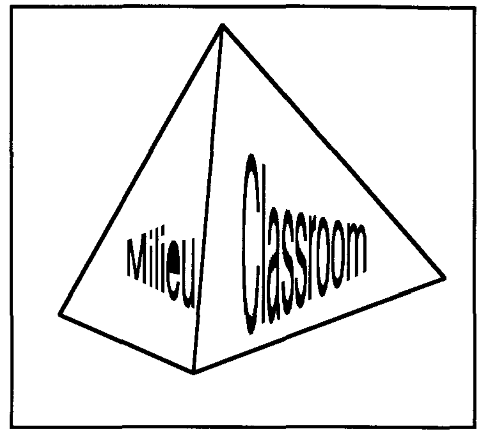

Figure 12 Distortion of Classroom.

This inability to achieve a simultaneous face-on view of multiple facets is an underlying cause for the failure of effective reform. This failure reflects the fundamental nature of education—that it is a self organizing system. The illusion that the system can be somehow *fixed* by tweaking a bit here and there only exacerbates the frustration of reformers. Reform, if it is needed, can only evolve from within the system as a whole. It cannot be caused in the sense of internal or external control from a controlling source. It may be that a gradual culture shift can achieve this. Though there will be a response to mandated reform, that response may be more negative than expected.

The effort to mandate *SchoolNet* is unlike the introduction of other teacher sponsored technologies into the classroom. It is not the result of Cuban's "technology-minded reformers" from within the classroom. It is imposed by political "technology-minded reformers." The legislators in the Ohio Assembly have succumbed to the kind of misshapen two-facet-view while attempting to rationalize accountability (the Feedback facet) to constituents (the Milieu facet) in their response to the *America 2000* rhetoric.

SUMMARY

Two lenses have been constructed which can help shift outlooks on technology changes in education. One demonstrates that the persistence of a cognitive illusion unbalances the natural tension between reality and illusion, blurring the distinctions between them. The other establishes the difficulty in trying to conceptualize change without distorting adaptation to change.

Awareness of the insidious nature of cognitive illusions is vital to making reasoned judgments that support the actions necessary to aim the educational flock toward whatever collective goal it chooses. A suggestion challenging IQ as anything other than a mathematical construct (as it is currently understood within the culture) is given verbal acknowledgment and, at the same time, it is denied through behavior by relying heavily on test results.

If examined closely, the four facets of the institution Education are not equal in sovereignty. The imbalance is initiated by the *agents of milieu*, which has the strongest influence within the system as evidenced in *SchoolNet* and proficiency testing.

CHAPTER 4—UNDERSTANDING *BETWEEN*

INTRODUCTION

In Education, change is manifested through revisions that respond to expanding social structures. Such change does not always build on a preceding change. The revision cannot be viewed as progressing to some coherent goal in either a linear or a building-block fashion (i.e. one idea leading to another, better idea; leading to or being added onto by another, better idea). In education, change means *reform*; replacing the old with something new. Reforms become solutions to needs or as adaptations to altered states—actions rather than causes. The pattern of reform reflects a dominant pattern in Western history.

Plato's Academy with its Socratic dialectic was parochially Athenian, creating a vision of the ideal city state while placing abstract and concrete concepts in a disembodied idealization. The Lyceum, successor to the Academy, was less parochial in that Aristotle expanded thinking into a deductive science that altered Platonic universals, bringing them down to earth. Later, Scholasticism established the Church Universal on the ruins of the Roman Empire, and allowed for a model that became the university structure of today. The Renaissance, Reformation, and the development of Capitalism were accompanied by a diminution of the primacy of deductive reasoning, making way for an empirical scientific method and the Industrial Revolution.

Over time, cultural transformations increased with expanding organizational complexity. Aristotle found it necessary to re-form Plato's abstract idealism through concrete experiential observations while Alexander, his pupil, was expanding the political concept of the city-state into one of *world-state*. Aristotle's *physics-metaphysics* fragmentation cannot be inferred to have been caused by Alexander's conquests, but some sort of mirroring interaction with the times might well be argued. By the end of the

Renaissance the concept of *re-forming* resulted in the explosion of sects in the Reformation with a corresponding eruption of *knowledge* fired by moveable type and the printing press.

Overt technological changes rather than religious, political, or philosophical forces dominated the larger societies of the 19^{th} and 20^{th} centuries. The consequence is a reformulation of the definition of wealth. In the later half of the 20^{th} century, a new meaning of wealth dramatically appeared. Where once wealth was defined as ownership of property or ownership of the means of production, it is now defined as intellectual capital and acquired within the frame of technology. Intellectual property is the benchmark: Bill Gates and Steve Jobs replace John Paul Getty and Andrew Mellon as icons of *the wealthy*.

The rationale behind the mandate to place technology in the schools follows this trend to identify success and wealth with the technology. Its logic builds on the rapid social and economic changes that are global in nature: A complex technology drives change; a new kind of worker must be trained for the technology; training is the purpose of schools; therefore, that training must begin in the school. The recommendations of *America 2000* embody this thinking.

In the effort to improve the competitive stature of the state or nation in the global economy, legislative reformers have introduced reform by fiat. This political response confuses a noun with a verb; the invention with the inventing; the technology with its creation. In doing so the politicians have changed the balances or tensions within the tetrahedron. In doing so they have bared an almost universal and fundamental misunderstanding of how human learning occurs.

THE CULTURE MODEL OF LEARNING

As we have seen, in the 20^{th} century school culture any of the new technologies appearing in the classroom generally originated through educators who saw a potential for improving the delivery of the curriculum. In spite of Cuban's assertion that technology is uncritically embraced by teachers, use of any device has always been optional; the classroom teacher did have a choice. When teachers discover that the effort to use a new device outweighs the benefits received, they reduce or abandoned its use. In any case, no technology, new or old, was universal.

The exception to that pattern was the *blackboard*, introduced in the 1840s. By the end of the century, it was an accepted essential element of the classroom. Even today, in some of the older Youngstown city schools that I have visited, blackboards cover all accessible wall space. But, blackboards were not adopted by the legislature: Teachers demanded their presence. They were universally seen as an aid to curriculum and instruction. The driving force did not proceed from the economy—local, regional, national, or global. The drive sprang from the needs of the institution—teachers simply found that the blackboard assisted in instruction.

The new driving force, passed down from above, is a reflection of the prevailing understanding or collective mental models of what happens in the classroom exchange between teacher and pupil. Whereas the term mental model is applied to individuals and is idiosyncratic in nature, it does not quite describe the more inclusive idea I have in mind. There is a label that better describes a collective understanding that is made up of collective mental models. The term, *culture model*, is suggested by Bradd Shore's (1997) cultural model which he defines as "patterns that govern conventional behavior and that [a society] largely took for granted (p. 6)." His definition covers a whole culture or society such as the Samoans. My meaning covers only sub-cultures such as that embraced within my tetrahedron culture, Education. The ideas are very similar; differing mostly in scale.

The most common metaphor used in the education culture model for what happens in the teaching/learning exchange is one in which the teacher *pours* knowledge into the student. This romantic picture of the student as vessel is also expressed in a variety of mutations. A teacher may declare that he has *given* his pupils the *tools* for success. Or, the imagery may involve a discipline like architecture through references to *foundations* and *building blocks*. Paulo Freire (1970/1993) used a banking metaphor in a telling argument against those who envision the student as only a receiver or a repository of knowledge:

> Education thus becomes an act of depositing, in which the students are the depositories and the teacher is the depositor. Instead of communicating, the teacher issues communiqués and makes deposits which the students patiently receive, memorize, and repeat. This is the "banking" concept of education, in which the scope of action allowed to the students extends only as far as receiving, filing, and storing the deposits. They do, it is true, have the opportunity to become collectors or cataloguers of the things they store. But in the last analysis, it is the people themselves who are filed away through the lack of creativity, transformation, and knowledge in this (at best) misguided system (p. 53).

Freire's reference to the student as "cataloguers" has as its consequence intellectual marginalization. The people—the aggregate of students in maturity—will be "filed away." This is the price of passive learning. It is the price of the pouring (banking or whatever imagery) metaphor. To echo the 1983 Commission's charge: If an unfriendly foreign power had attempted such a marginalization, we might well have viewed it as an act of war.

The imagery of the student as receptor is simplistically deceptive and is the genesis for the "conflicting purposes of schooling" cited by reformers. Many of these conflicts rise from outside education when other impositions unrelated to the learning process are proscribed by the courts (e.g., special education problems best handled by trained psychiatrists are seen as the province of less expensive pseudo-psychiatrist teachers), or when structural changes are made that are inspired by do-good sectarian special interest groups (e.g., voucher schemes). In this almost universal culture model, the learning *process* is confused with the acquisition of pourable facts. Experiential memory is confused with memorizing a catechism.

While using varied imagery, David Shenk, in *Data Smog (*1997a), presents the pervasive pouring metaphor when he broadly summarizes and depicts the narrow scope in which that metaphor is supposed to work:

> Schools are stringent filters, not expansive windows onto the world. Teachers and textbooks block out the vast majority of the world's information, allowing into the classroom only very small bits of information at any given time. When organized well and cogently presented, these parcels of data are metamorphosed into building blocks of knowledge in the brains of students (p. 75)

To that summary I would add that the driving mechanism behind the pouring hand is the one that places high scores in dubious tests at a premium. It is a mechanism that places Stratfield Elementary School in national headlines.

THE CULTURE MODEL OF REFORM

Whatever evolutionary event that set *homo sapeins* apart from other mammals happened at least 117,000 years ago. Year one of the *Era of Man* (EM) is an event that may have been triggered by the ability to remember and use past experiences; it may have been the use of the language tool; it may have been something in the ecology or genetic mix—the theories abound. While biologically similar to cousin species, *homo sapiens* were different in a major way that did not truly flower for well over 100,000 years.

At some unrecorded point(s) one or more *cultural* events happen. In adapting to the challenges of survival, the social structure begins to be more complex. Eventually there is an emergence. Cities form. Economies form. States form. Over time the complexity increases to the point we experience today. Education in any embodiment that we would acknowledge as being close to our concept began with Thales and Aristotle, and, Lao Tse and Confucius around 114,500 years after the initial event. William Farish breaks a 425 year old Oxford tradition by ushering in thought evaluation around the year 116,800 EM. The Ohio General Assembly mandates *SchoolNet*, circa 116,993 EM.

At some point in that 117,000 year journey the hunter gatherer culture adopts an efficient learning tool. It is built on a three-stage hierarchy with an elder master hunter (or gatherer) at the top. The young learn fundamentals at an entry level as apprentices. Perfection leading to the master level is achieved through a middle stage as journeyman. While this tool may have its genesis in the innate survival learning techniques of the individual infant, the progression from gross skill to refinement underlies all learning. The fundamental nature of this tool seems to be so obscured in current sophisticated pedagogy that it appears to be forgotten. The journeyman stage, especially, is a casualty in the rush to quantify learning and to make schools scientifically efficient.

An argument might be made that schools are structured on just such a three tiered model. The teacher is the master; the pupil, the apprentice; and, the curriculum is structured in a spiral that starts at gross levels and proceeds to ever narrowing levels of refinement. On close examination of practice, however, the pouring metaphor dominates, and two discrepancies are immediately apparent. Unlike the hunter-gatherer apprentice, the student is at best a passive agent in the learning; and, the cognitive illusion that drill-and-practice can substitute for growth by doing is no substitute for an active journeyman stage. The passive student is marginalized in Freire's sense, and the political or economic aim of global equity is unwittingly compromised.

However, some reformers are recognizing the importance of an apprenticeship approach to learning. In the forefront of these, Howard Gardner (1991) advocates incorporating the concept through immersing the young experientially in:

> an educational environment in which youngsters at the age of seven or eight, in addition to—or perhaps instead of—attending a formal school, have the opportunity to enroll in a children's museum, a science museum, or some kind of discovery center or exploratorium. As part of this educational scene, adults are present who actually practice the disciplines or crafts represented by the various exhibitions. Computer programmers are working in the technology center, zookeepers and zoologists are tending the animals, workers from a bicycle factory assemble bicycles in front of the children's eyes, and a Japanese mother prepares a meal and carries out a tea ceremony in the Japanese house. Even the designers and the mounters of the exhibitions ply their trade directly in front of the observing students (p. 200).

This concept is not as passive as the quote implies. Gardner would have the students serve a group apprenticeship (e.g., assembling bicycles under the tutelage of the workers). The vision, however, suggests a paradox. These experiences are beyond the current nature of schooling, which, as Shenk points out, is much narrower in practice. The experiences of building a bicycle can only be considered as a supplementary enrichment to the curriculum. They are interesting as experiences but not always useful for cognitive development.

The paradox in Gardner's vision is inherent in the visions of most reformers. They base reform on the naive idea that their change need only be made in one or two facets of education (e.g., Classroom or/and Training). This is a culture model that works not only against the immediate reform but also creates a climate for cynicism toward any reform. One need only recall the widespread problems created by the so-called new math and transformational grammar fiascoes to understand that no matter how worthy or desirable a change may be, it will not happen without universal change—change in all four facets of the institution.

The effective pattern of this culture model is not confined to education. It echoes in other sub-cultures throughout the greater society. Industry can serve to illustrate the point. Although they carry different labels, the interdomain facets of the industrial culture must be considered if change is to occur there. In spite of the widespread acknowledgment that industry in the United States is out of step with most of the rest of the world, the movement to change to a metric standard failed overwhelmingly. The arguments that a universal system would be more efficient and would remove a major barrier in world commerce were insufficient for adoption. The change was perceived with blinders favoring short term profit and nationalistic bias.[21]

The culture model of reform is shaped by the realization that the old way is not working, and through the way(s) in which breakdown is manifesting itself. In the current milieu, the signs of malfunction usually originate overtly in the news media, but the classroom teacher is probably the first to experience the sense of disquiet. This feeling develops as an intuitive reaction to an awareness of a new inability for students to cope. Trickle-down blame (upper grade levels faulting lower levels) is the usual reaction and the problem is left unaddressed. Administrators are unresponsive to those teachers who remark on their disquietude. It is not until the press dramatizes (and misinterprets) test scores that reform is considered.

The method used to resolve the problem is usually determined by a narrow frame proscribed by the reformers' discipline bias. Gardner's formulation is expansive when one considers the narrow lenses used by such reformers as Alan Bloom (1987), E. D. Hirsch, Jr. (1987), and Mortimer Adler (1982, 1983, 1984). The most structured of these is Adler's *Paideia Proposal*. Under the assertion that democratic fundamentals can only be cultivated and preserved through a one-curriculum-fits-all Western liberal arts content, Adler and his committee[22] mix desirable (but somewhat narrow) teaching strategies (Adler, 1982, p. 23) with a content relevant only to an elite segment of college bound candidates (Adler, 1984, Appendix). The methods mix traditional lecture (pouring) and coaching (drill and practice) with a rarely practiced Socratic dialectic.[23] The content reflects a reliance on anachronous cultural artifacts and mythologies that border on totemism. Such reform defeats the idealistic goals of the advocates, not just by their irrelevance to the majority of students, but also by failing to foster the learning and thinking skills that are the fundamental mission of education.

The culture model of reform also assumes that formal learning begins in Kindergarten at the age of five and at a uniform ground zero of experience. This is the traditional way of looking at the education time line. It is based on the belief that state intervention in a child's intellectual development is inappropriate below a certain age and is historically rooted in the Spartan model in ancient Greece. Until the modern era it was advantageous, for moral, religious, political, and economic reasons, to have the care and training of infants and very young children handled by mothers or other care givers within the family unit. In the latter quarter of the 20^{th} century these parameters supporting this practice may not be so clearly determined or defended (Botstein, 1997). Experience has shown that the haphazard quality in training of the very young has resulted in the need for large intervention programs.

Assuming a ground zero at the age of five or six—a common denominator starting level for all—is a cognitive illusion. All are not created equal. All cannot be expected to learn at the same level or within the same chronological frame. All are exceptional, but that does not mean that all are of the same capability. Some reformers accept and recognize that there are differences in capacity, but insist that content must be the same.

Of these Adler is an articulate spokesman. When asked: "Do the members of the Paideia Group really believe that [their basic, classical, humanities curriculum] is applicable to all—all without exception (Adler, 1983, p. 31)?" Adler accepts differences of degree of ability but insists that the content cannot be compromised. In responding to the question, he offers the ubiquitous pouring analogy:

> If containers differing in their capacity, ranging from half-pint containers up to gallon containers, are all filled to the brim, they are all equally full, for each is full up to its initial capacity. But if some of the containers, those that are least capacious, are filled to the brim with water; if some, slightly more capacious, are filled with skimmed milk; if some still more capacious are filled with whole milk; and if only the largest containers are filled with rich cream, then their being thus filled to the brim results in a difference in kind, not just in degree.
>
> Our position is that all the containers, differing in degree of capacity, should not only end up being filled to the brim, but that all should also be filled with the same substance—with a half-pint of cream in the half-pint container and a gallon of cream in the gallon container (p. 32).

Continuing the analogy, this suggests a question of digestibility. Not all stomachs can handle cream. What academic lactase is available to mediate the effects of lactose intolerance?

The culture model that fails to acknowledge and respond to change—that assumes a one-curriculum-fits-all stasis, that believes that the most efficient means of teaching is by deskilling teachers, that intelligence can be quantified—reflects a culture that is unprepared for reform by technology. To respond to the technology a new culture model must be formulated. It need not be radical, but it will need a strong vision of the whole of education—not just a vision of the *purpose* of education. That vision must include a firm understanding of the broad features of how humans learn.

CONSTRUCTING LEARNING

Logic and Mathematics

As pointed out, new sciences are evolving that cross traditional barriers. The impetus for their development is a realization that the fragmentation of knowledge disguises a lack of knowledge. Missing is the *information between.* Cognitive science, for example, attempts to recover the information between disciplines as it seeks to connect six unrelated sciences while exploring the workings of the mind and the brain. Instead of the split between Aristotelian physics and metaphysics it melds the two as it seeks a physical answer to epistemological questions.

Within the disciplines of cognitive science, there is a close, almost symbiotic, alliance between those working in the areas of cognitive psychology, linguistics and neuroscience, and those pioneering in creating artificial intelligence (AI). This relationship is not always overt, but experimenters find that discoveries in one domain are relevant to activities in the others. Many of the advances in current understandings result from this connectivity which was inspired and propelled by failures experienced when AI developers attempted to translate the biological into the mechanical.

Early AI failures can be attributed to a culture model that views the mind and brain as operating like a computer. The culture is mathematics driven by a Newtonian-Cartesian mechanical vision of the universe dominated by linearity and polarity. The problem is not in the validity of mathematic models. The problem rests more in the inflexibility of those models. This is especially true in the computer algorithm which is based on that binary system. The algorithm uses sequences of voltage on/off combinations to program solutions to tasks designated by the user.

For calculating the trajectory of a missile, for drawing a picture, or for writing term papers the linearity of the algorithm is generally more than adequate. Even with large masses of data which are actually stored linear in memory, access to any one item anywhere can be made rapidly and, if desired, at random. In most software, the user feels in control and has the illusion that the computer understands what is being done. But, for all the apparent similarity to how humans think, the computer is incapable of performing at a level comparable to one that a two-year old would find simple.

The common belief that the mind is like a computer just is not so—in either direction. Humans are not like computers and computers are not like humans. Humans do not think in a linear fashion and do not store information in linear structures. Bradd Shore points out that the brain "is an adaptive opportunistic information processor that transforms its data into meaningful patterns (Shore, 1996, p. 7). " The computer lays down data in predetermined structures—a process that is not even exteroceptive since the computer has no choice. In the mind, storage patterns are self organized and self generated—proprioceptive

Black and white dichotomies work well within the frame of a logic that prizes the isolation of parts from the whole—scientific empiricism. When the unforgiving mathematics of Aristotle or Descartes is employed to give legitimacy to a theory or hypothesis, the separation from reality is exacerbated. That form of logic falls apart completely within a frame of complex systems—reality. This is why a reform like the *Paideia Proposal* can only hope to a very low level of success. With all its complexity and worthwhile methods, there is an *all or not all* philosophy in the core argument.

Thomas Kuhn (1962/1970) pointed out that accepted and successful scientific theories and their proofs explain the majority of phenomena in a given class. He argues that, while the majority of cases can be satisfied with a given paradigm, occasionally scientists meet the limits of the paradigm—events that the paradigm cannot explain without major adjustment. This can result in a "scientific revolution." In the most frequently cited example, the Ptolomaic geocentric concept, the mathematics could not easily account for the apparent wobbling of planets. The paradigm was based on the observable *truth* that the sun traverses the sky around the earth, rising and setting in the course of a day. Once Copernicus postulated heliocentric orbits, the mathematics fell in place. Nothing really changed—the sun continued to *rise* and *set*—but the planets did lose their mathematic wobble. The old paradigm *shifted*, replaced by a new paradigm.

Not all paradigms are replaced when a shift in focus occurs. A revolution can create a new science or mathematics, leaving the old valid and in place. Einstein's physics did not replace Newton's. A new science or mathematics, with the improbable and in-your-face name *Fuzzy Logic* (assigned by originator Lofti Zadeh [McNeill & Freiberger, 1993]), is such another revolution. It attempts to describe the logic between black and white—the gray area of ambiguity. The Western logic of Euclid, Euler, Bayes, Boole, and Descartes is relevant to the computer as it is commonly understood to operate. It is not relevant to understanding the workings within the brain and, by extension, it is not relevant to creating an artificial intelligence. More important for educators, it interferes with understanding the mechanics of learning.

Fuzzy Logic was not developed in a vacuum. The need for a way of describing ambiguity, evaluating the abstract, or exploring the between of all and not all has been a weakness in Western thought and a challenge to accepting the validity of Eastern ideas (Kosko, 1993). Kieth Devlin (1997) argues the necessity for a mathematics of this kind pointing out the resistance from traditionalists.[24]

> Many scientists and mathematicians, trained in the traditions of their fields, throw up their hands in horror upon hearing someone claim that we need to look for ways of understanding that go beyond the limits of the traditional methods of science and mathematics and that challenge some of the basic assumptions of science going

> back to Plato, Aristotle, Descartes, Galileo, and Bacon. Used to the tidy compartmentalizations of traditional science, they generally put such suggestions into the "fringes of science" bag, along with astrology, New Age medicine, California hot-tub encounter groups, Zen philosophy, space aliens in UFOs, and what have you. . . . [T]o the dyed-in-the-wool physical scientist, all of the pursuits mentioned share the same, "unscientific" flavor and as such are dismissed as irrelevant pastimes that cannot possibly lead to any real understanding of the universe or the people and other life forms in it.
>
> . . . [A]long with a significant and steadily growing number of individuals trained in the traditional sciences and mathematics, I have gradually come to realize that, tradition aside, in trying to develop an understanding of mind and language, we have probably come up against the limits of the traditional frameworks. I don't think this necessarily means that there cannot be sciences of the mind and language, nor does it mean that there will be no role in such sciences for mathematical and other traditional scientific methods. But it does mean that the new sciences will almost certainly have a different look and feel to them (pp. 282-283).

This different looking science and mathematics is used to describe the current understanding of the way the brain works. Instead of on/off states, as in the computer/brain popular culture model, weighted values represent functioning distributed within a vast diversity and complexity of neural networks. In memory locations, for example, strength of a memory is dependent upon the strength of the network supporting the memory. These networks build in a bottom-up rather than a hierarchical top down, rule driven manner. The weights or strengths can be understood to originate as vectors of data received through the senses (Churchland, 1996).

This image, the mind constructing itself, should have a major affect on the classroom teacher. It changes the meaning of the verb phrase *to teach*. As pointed out, the current culture model is linear. Facts are poured into the student in a top-down sequence. The teacher is the source of motivation. In the new image, the individual learns by constructing knowledge, building it through networks of relationships. This constructionism begins at birth if not before. Jean Piaget and Lev Vygotsky pioneered that concept.

Genetic Epistemology

The nascence of cognitive science *theory* is generally placed in the 60s and 70s. Howard Gardner (1985) suggests that the embryo was formed in September of 1948 with the presentation of a paper by Karl Laskey at the Hixon Symposium at the California Institute of Technology. Laskey challenged the dogma of behavioral (associative) psychology which held a blind belief in the universal integrity of the scientific method movement (Chap. 2).

The *practice* of cognitive science can be said to have been initiated in 1920, when Jean Piaget joined Theophile Simon at the Binet Laboratory in Paris. Although Alfred Binet was no longer in the picture, the Binet Laboratory continued the work in *intelligence* testing that he initiated and developed with Simon. During Piaget's stay, he came to realize that the quantification of intelligence was flawed. This conclusion was the result of the convergence of three perceptions (Ginsburg & Opper, 1969).

The first came within the frame of the testing method in operation at the time, which centered around correct answers. He came to believe that:

> [T]he child's *incorrect* answers were far more fascinating. When questioning the children, Piaget found that the same wrong answers occurred frequently in children of about the same age. Moreover, there were different kinds of common wrong

answers at different ages. Piaget puzzled on the meaning of these mistakes. He came to the conclusion that older children were not just "brighter" than younger ones; instead, the thought of younger children was *qualitatively different* from that of older ones. In other words, Piaget came to reject a quantitative definition of intelligence—a definition based on the number of correct responses on a test. The real problem of intelligence, Piaget felt, was to discover the different methods of thinking used by children of various ages (p. 3).

The second understanding developed within the testing procedure to replace the operant one. Having rejected the standardized test approach:

. . . he sought a less structured method which would give him more freedom to question the child. His solution was to apply to the task his previous experience in abnormal psychology: he adapted the psychiatric method to research into children's thought. The new method was extremely flexible. It involved letting the child's answers (and not some preconceived plan) determine the course of questioning. If the child said something interesting, then it would immediately be pursued, without regard for a standardized procedure. The aim of this method was to follow the child's own line of thought, without imposing any direction on it (p.4).

The third insight grew from his readings in philosophy and logic:

It occurred to him that abstract logic might be relevant in several ways to children's thinking. He noticed, for instance, that children younger than about 11 years were unable to carry out certain elementary logical operations. The possibility of extensively investigating this apparent deficiency immediately presented itself. Also, Piaget felt that thought processes form an integrated structure (not a conglomeration of isolated units), whose basic properties can be described in logical terms. For example, the logical operations involved in deduction seemed to

> correspond to certain mental structures in older children. He set himself the goal of discovering how closely thought approximates logic. This was a unique conception of the psychology of intelligence (p. 4).

Piaget's broad theory of stages of development grew from these intuitions. This theory, unfortunately, has been subject to misinterpretation: Some of this has been generated by misunderstanding simple terminology (the term *egocentric* is often interpreted to coincide with Freud's meaning and use; Piaget's meaning cannot be the same because the child (infant) either has no sense of self (early) or is (later) just developing the self), and some misunderstanding rises from the common scientific error of thinking in terms of averages instead of commonalties (Kitchener, 1986). As I have observed my peers, other errors arise from wishful thinking resulting from poor training (literally applying the concept of constructionism in the infant to fit a pedagogical goal regardless of age and appropriateness).

To further confuse a cogent understanding of Piaget for those exposed to his theories, the theories themselves were modified over time and some experimenters seem to fail in their attempts at duplication. Educational psychology texts may use as primary source material ideas that reflect the writings of early Piaget, overlooking the later writings that may contain clarifications or revisions. While failure to duplicate specific experiments is serious to the literal empiricist, nothing has changed the overall legitimacy of the corpus. I would offer that such failures could be cultural. Anthropologists have found that the Müller-Lyer illusion (Figure 1. above) does not show the same persistence in "[non-]carpentered environments" as it does for us (Shore, 1996, p. 22). American children in the later half of the 20th century may not perform the same way as French children in the first half of the century.

As with all pioneers, Piaget indicated a direction. That direction was away from the behaviorist belief that bird brains and human brains are somehow comparable when learning. Piaget's contribution does not rest on quibbles over whether there are three major stages (Gardner, 1981/1972) or there are four major stages (Ginsburg, et al., 1969). Nor is it advantageous to conceive a model that ascribes time constraints or limits for each stage. He demonstrated conclusively that children are not just little adults. The way the child thinks goes through changes that the child constructs as it seeks to make sense of its world. It is a trial-and-error process (bricolage) that is often wrong when judged through adult understanding and knowledge. This *wrongness* must be allowed to persist in spite of the adult desire to *correct* error. The course cannot be short circuited without subverting a normal learning process.

Recent conclusions about neural activity suggest that this is as true in the later stages of learning as it is in infancy:

> We have all heard of the well-meaning but overcompetitive parents who try to get little Nancy to start learning calculus at age six or who send little Billy to violin camp at age three. That kind of excessive educational pushing can cause levels of anxiety in the child leading to the release of stress hormones. And those kinds of body chemicals can actually destroy neurons (Davis, 1997, p. 64).

Piaget viewed himself as a genetic epistemologist above all. He sought a physical answer to how humans learn. He sought answers to such questions as: "How is it possible . . . for the necessary truths contained in logic and mathematics to result from the contingent ones the child first encounters (Kitchener, 1986, p. 99)?" While centered around epistemology, his search was multidisciplined, and therefore within the formulation of cognitive science. This method embraces his training in biology, psychology, as well as philosophy (Kitchener, 1986). The common American view that he is *only* a developmental child psychologist understates the contribution a closer reading of his work could make to education. Combined with recent understandings of how the mind/brain functions, a richer vision of how technology can be incorporated into the curriculum can evolve.

In his impressively documented debate with Noam Chomsky (Pattelli-Palmarini, 1980),[25] Piaget summarized his conclusions about the active participation that is so fundamental to his constructivist theory of learning:

> Fifty years of experience have taught us that knowledge does not result from a mere recording of observations without a structuring activity on the part of the subject. Nor do any a priori or innate cognitive structures exist in man; the functioning of intelligence alone is hereditary and creates structures only through an organization of successive actions performed on objects. Consequently, an epistemology conforming to the data of psychogenesis could be neither empiricist nor preformationist, but could consist only of a constructivism, with a continual elaboration of new operations and structures (p. 22).

Since language is the first major construct for humans, the question of how it can be explained is crucial to understanding future constructs. Chomsky argues that language is innate—somehow wired into the mind. He believes "that a genetically determined language faculty, one component of the human mind, specifies a certain class of 'humanly accessible grammars.'" (Chomsky, 1980, p. 35). His argument parallels Descartes' separation of the mind and brain, where the mind is seen as a kind of ghost operating the brain. Chomsky's language-faculty ghost is deduced from the universality of a subject and predicate (S→P) structure from which other strikingly similar language structures are built, giving rise to the idea of an architypical or prototypical language. A superficial identification of the Broca and

Wernicke areas might give credence to the theory, for they are brain regions associated with speech interpretation (language) (Calvin, 1996).

If Chomsky is right, other representations must also be innate. Nature has a habit of replicating things that work and adapting them to serve other functions. It turns out that more than one region in the brain seems to be similarly activity specific. There is a region where face recognition resides, for example (Churchland, 1996). If Chomsky is right humans will identify faces at some basic level such as at the male and female (M→F) difference. If the language organ has a built in S→P feature, the face recognizing organ must have a basic feature like a possible M→F—and, likewise, the logic center must have numbers, and the color center, colors. No such parallel innateness has been observed. Faces and all the complexity of recognition and classification begin in infancy.

Language development does originate *within* the human organism, but it is a proprioceptive exploration of the child's environment that is involved, not some innate language drive or center. Terrence Deacon (1997) asserts that Chomsky and other linguists have made the wrong assumptions. Language adapts to the workings of the child's brain rather than the brain molding language. He points out that " Language evolution is probably thousands of times more rapid than brain evolution. Such a vast difference in evolutionary mobility suggests that we may have assumed that the wrong half of the evolutionary equation contained the critical variables (p. 110)." Furthermore, the consequences of interrupting the exploratory process can be disastrous. "If a child has not been exposed to language and begun practicing those skills by the time he or she is three or four years old, the child will never possess normal language (Davis, 1997, p. 62)."

Piaget's focus is on all learning, not just the learning or origins of language. His intuition about human constructionism has a biological and neurological foundation. The mechanics (e.g., how any learning is internalized, weighted, and stored) are becoming more clear. They occur and their affect can be described. Churchland's sensory vectors seem to satisfy the mathematics in a representational model. Computerized tomography (CT) and magnetic resonance imaging (MRI) are just two techniques used to map the physical phenomena (Davis 1996).

The Zone of Proximal Development

A second pioneer-practitioner of cognitive science approached learning through language and within a socio-historic frame. Lev Vygotsky's early career combined teaching literature with teaching psychology. This combined interest, pedagogy, literature, and psychology, led him into the areas of defectology and mental abnormality and, as with others (e.g., Piaget and Montessori), into the questions of normal learning by way of the abnormal. Early in his studies he saw the strong connection between language and intellectual development. Like Piaget he rejected methods that focused on behavior over process in learning. Although their avenues of approach were quite different, their broad conclusions are remarkably similar. Unlike being opposite sides of the same coin, they are different coins of the same denomination. From them, flows a double value.

Vygostsky rejects the common uses of animal study, physiological or psychological, that find analogy between human and animal development. He says that doing so limits the experimenter to the passivity of normal maturation at the exclusion of the "higher psychological processes (Vygotsky, 1978). Far from being xenophobic, he is attempting to demonstrate that the developmental process in humans is actively beyond mere animal behavior in complex ways.

Biological support for the intuition behind this approach is simple enough. Unlike the other primates, 75% of the physical growth of the human brain takes place after birth and is fully realized at puberty. In the other primates between 45% and 60% of brain growth occurs in the womb and full development is achieved years before it does in humans (Shore, p. 3). But the organ brain in the human is not limited to a passive growth. From birth the brain is developing a function generally separated out as *mind*. This function continues to advance through a lifelong process of learning. While learning can be said to occur in primates and other animals, there is quantity-quality kind of contrariety that differentiates humans from even their closest cousins. There is a point at which the difference occurs.

Vygotsky identifies this point as "*. . . the most significant moment in the course of intellectual development, which gives birth to the purely human forms of practical and abstract intelligence,* [and that] *occurs when speech and practical activity, two previously completely independent lines of development, converge* (p. 24, emphasis in the original).

He identifies speech with thought. Taking his cue from Marx, he identifies practical activity with the use of tools. He goes on to explain:

> Although children's use of tools during their preverbial period is comparable to that of apes, as soon as speech and the use of signs are incorporated into any action, the action becomes transformed and organized along entirely new lines. The specifically human use of tools is thus realized, going beyond the more limited use of tools possible among the higher animals (p. 24).

Although Vygotsky seems to disagree with Piaget on the question of transience in Piaget's concept of egocentric speech (Vygotsky, 1934/1962), his thought does appear to parallel Piaget's idea that egocentric speech, in conjunction with activity, is a necessary part of the constructive learning process, at least in the early stage(s). The egocentric speech here can be identified with thought. The tool of thought is language. And language is organized around the S→P relationship. The subject is generalized as a thing, an object or an idea—a noun. The centrality of the noun is shared by its activity through the predicate—verb—in thought. The noun does not exist without the verb. They are bonded as N⇔V.

The culture model of learning holds that intellectual development is like maturing. The child grows or matures intellectually into an adult. Both Piaget and Vygotsky deny the child is a small adult that needs only "to grow up" through experience. This is evidenced when the child fails to meet adult expectations. There is a gap or "advanced stage in the development of word meanings [which is why] certain thoughts cannot be communicated to children even if they are familiar with the necessary words (Vygotsky, 1934/1962, p. 7)."

Vygotsky advances the concept that intellectual development is dialectical. He argues:

> Our concept of development implies a rejection of the frequently held view that cognitive development results from the gradual accumulation of separate changes. We believe that child development is a complex dialectical process characterized by periodicity, unevenness in the development of different functions, metamorphosis or qualitative transformation of one form into another, intertwining of external and internal factors, and adaptive processes which overcome impediments that the child encounters. Steeped in the notion of evolutionary change, most workers in child psychology ignore those turning points, those spasmodic and revolutionary changes that are so frequent in the history of child development. To the naive mind, revolution and evolution seem incompatible and historic development continues only so long as it follows a straight line. Where upheavals occur, where the historical fabric is ruptured, the naive mind sees only catastrophe, gaps, and discontinuity. History seems to stop dead, until it once again takes the direct, linear path of development (Vygotsky, 1978, p. 73).

His learning path is seen as recursive and irregular not linear or even curvilinear.

This cyclic nature of learning creates two levels of development. Vygotsky points out that the first is the one assumed in developmental studies determining mental age. It "... can be called the *actual developmental level*, that is, the level of development of a child's mental functions that has been established as a result of already *completed* developmental cycles (p.85 emphasis in the original)." The second is a less determinate level and because of its fuzziness is most often ignored by the empiricist. However this stage is vital for the teacher in understanding the child's true intellectual status.

Vygotsky offers a simple experiment to illustrate his point. He posits two children whom he tests and finds equal:

> Now imagine that I do not terminate my study at this point, but only begin it. These children seem to be capable of handling problems up to an eight-year-old's level, but not beyond that. Suppose that I show them various ways of dealing with the problem. Different experimenters might employ different modes of demonstration in different cases: some might run through an entire demonstration and ask the children to repeat it, others might initiate the solution and ask the child to finish it, or offer leading questions. In short, in some way or another I propose that the children solve the problem with my assistance. Under these circumstances it turns out that the first child can deal with problems up to a twelve-year-old's level, the second up to a nine-year-old's. Now, are these children mentally the same (p. 86)?

The culture model might counter that the experimenter's interference *taught* the children bringing them to the new levels. Vygotsky would argue that assisted problem solving establishes the plateau of *potential* for learning. It is a region where learning can take place. It is the region teachers should be addressing with students. Vygotsky calls this region of potentiality, the *zone of proximal development.*

There is a third level implied in this theory. It is the level beyond the child's immediate grasp—beyond the limit of the zone of proximal development. Without defining this region, Vygotsky recognizes its presence:

> [P]sychologists have shown that a person can imitate only that which is within her developmental level. For example, if a child is having difficulty with a problem in arithmetic and the teacher solves it on the blackboard, the child may grasp the solution in an instant. But if the teacher were to solve a problem in higher mathematics, the child would not be able to understand the solution no matter how many times she imitated it (p. 90).

Unfortunately the culture of learning model assumes all students are ready for the third region while many are trying to cope within the zone of proximal development.

When Vygotsky defines learning, he is not just describing the social interaction of question and answer that passes for dialogue in schools. His is a dialectic wherein ". . . learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers (p. 90)." These internal processes cannot be triggered by rote activities or through passive reading of the text. It is social and takes place within the context of the history of the individual. In this process developmental achievement is out of phase with learning, and learning is always lagging.

The culture model of learning is under the cognitive illusion that it practices within the Vygotsky model. The belief is that all who pass second grade reading, for example, are at the second grade reading level. Even discounting social promotion, all who enter the third grade are not equal. The third grade teacher proceeds as if they are, even though he knows they are not. The argument is made that to make a proper evaluation would take too long and be too expensive.

Figure 13. serves to summarize Vygotsky's concept of the zone of proximal development in relation to the actual development as determined by testing and the implied third region that is beyond the child. These three can also be viewed as the inverse of the archetypal apprenticeship model mentioned above, demonstrating the perverse nature of viewpoint, since the chronology is such that from the child's perspective mastery occurs first. This relationship, however, does emphasize the centrality of the journeyman stage for both teacher and pupil.

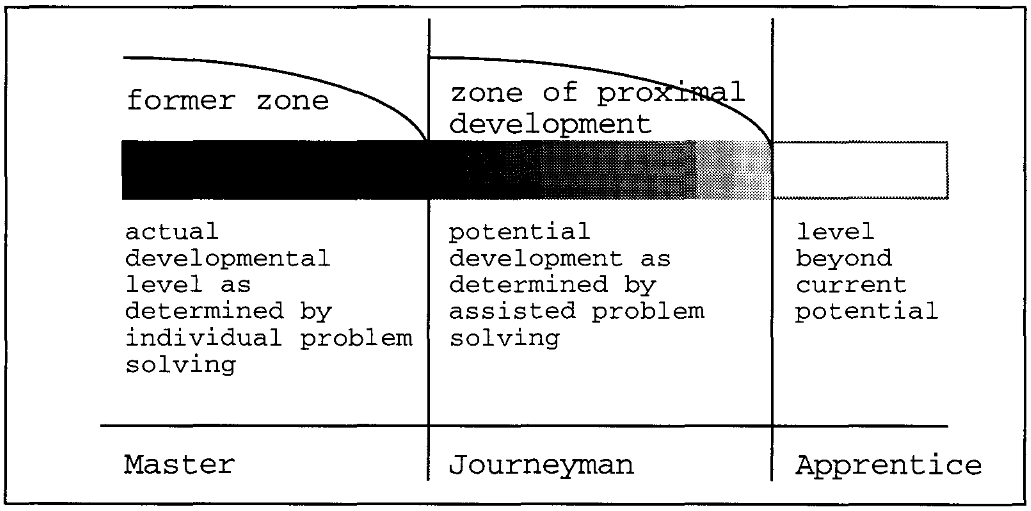

Figure 13. A placement of the zone of proximal development

Constructionism

The theme that dominates the work of Piaget and Vygotsky is one in which more than just individual knowledge or learning is constructed. It occurs simultaneously at two levels: the individual and the group. The process is idiosyncratic in the sense that the individual constructs knowledge internally and within the frame of a unique personal setting. It is social in the sense that the setting involves others who exchange a culture through language and modeling experiences. This concept of construction does not include the kind of linearity of purpose or method that is implied by the word itself, even though it is controlled largely by the culture and times. The elements of active participation and creation are fundamental. However, even with acknowledged goals it *happens* without the kind of orderly planning or organization associated with the terms *construction* and *goals*. Left to its own natural bent, it is messy and haphazard.

In an attempt to find coherence out of this chaos, the complex systems that make up societies evolve *schools* as a method of passing on whatever is considered worthy—whether for survival or some loftier purposes. Initially the method was characterized by a simple apprenticeship model forged out of *natural* learning. As social complexity increases, however, a mathematic/logical model evolves reflecting the human reflex to categorize. In the present extreme, the constrictions of mathematics imposes an artificiality bordering on totemism. This artificiality is at cross purposes with the constructive nature of the adaptive learning process. Based in behaviorist rote techniques, it tends to suppress, in all but the most clever, the connectivity necessary for psychological transference in or to "higher psychological processes."

Much has been learned since Jean-Jaques Rousseau (1762/1979) modeled the education of Emile on natural instincts. If anything, the history of the 20th century has demonstrated that natural instinct is not to be trusted. That does not mean that all natural cognitive processes are to be tamed into unnatural submission. Nor does it mean that every discovery or theory in cognitive science should be fossilized literally into pedagogic dogma (as happened in the right-brain and left-brain fad that seems to be with us still). It is as much an error to confuse a stereotype of the primitive with natural processes as it is to assume two brains in a theory of hemispheric asymmetry. It may be that reformers are so desperate that any straw will do to patch the damages from the behaviorist rote techniques mentioned above. Blind adoption of the faddish can lead to the ludicrous.[26]

Given a nominal birth through Seymour Papert's *Mindstorms* (1980), *constructionism* is built on the Piaget/Vygotsky model. Using LOGO, an early object oriented language that he fathered,[27] Papert introduced a new dimension to the use of computers in the classroom. He establishes the framework that fostered his sense of breakthrough:

> In most contemporary educational situations where children come into contact with computers the computer is used to put children through their paces, to provide exercises of an appropriate level of difficulty, to provide feedback, and to dispense information. The computer programming the child. In the LOGO environment the relationship is reversed: The child, even at preschool ages, is in control: The child programs the computer. And in teaching the computer how to think, children embark on an exploration about how they themselves think. The experience can be heady: Thinking about thinking turns the child into an epistemologist, an experience not even shared by most adults (p. 19).

This use of objects as tools for learning has been expanded combining Lego blocks with LOGO: Lego/Logo (Papert, 1993), refining LOGO: MicroWorlds (Papert, 1996), and simulating parallel processing and complex systems: *Logo (pronounced star logo) (Resnick, 1997).

When Vygotsky defines that special moment where "speech and practical activity . . . converge," he embraces tools as a necessary component in a generative sense—tools begetting tools. Yasmin Kafai and Mitchel Resnick (1996) affirm this relationship when they attempt to define and describe constructionism:

> Constructionism is both a theory of learning and a strategy for education. It builds on the "constructivist" theories of Jean Piaget, asserting that knowledge is not simply transmitted from teacher to student, but actively constructed by the mind of the learner. Children don't *get* ideas; they *make* ideas. Moreover, constructionism suggests that learners are particularly likely to make new ideas when they are

> actively engaged in making some type of external artifact—be it a robot, a poem, a sand castle, or a computer program—which they can reflect upon and share with others. Thus, constructionism involves two intertwined types of construction: the construction of knowledge in the context of building personally meaningful artifacts (p. 1).

Time Space

In practice, however, Papert and others who rely on the computer as tool seem to forget that it can only represent the world to the young child in two dimensions. The mathematics that Papert would have the child construct through procedures like TO HOUSE or TO FLOWER is not true to the geometry of either houses or flowers. In their enthusiasm to expand epistemological prescience, they forget that the child is not ready for thinking about thinking any more than she is ready for parsing sentences that she uses daily. Piaget repeats the caution that stages in development cannot be skipped nor forced. Doing so imposes adult expectations and behavior on the child who is not ready, frustrating the child, the teacher, and the natural progress of the learning process.

In the 20th century plunge into scientific thinking, programmed learning, and computer technology much of the culture's educational memory is maginalized. The theoretical work of Piaget and Vygotsky (as examples only) is ignored or distorted in practice. The practical paths shown by such pioneers as Pestalozzi, Montessori, and Dewey are either lost altogether (Pestalozzi), privatized (Montessori), or politicized (Dewey) into near oblivion. There are those who argue forcefully that this marginalization has resulted in an unretrievable loss of creative talent.

One of these is the architect and artist Norman Brosterman (1997) who makes a strong case that the character of 20th century art was invigorated if not changed by Friederic Foebel's concept of learning through objects. In his studies of some of the masters of this century he found that there was one commonality. They had attended a kindergarten based on the Froebel model. He suggests that the creative juices of artists Georges Braque, Paul Klee, and Piet Mondrian, and architects Le Corusier, Buckminster Fuller, and Frank Lloyd Wright were enhanced by the freedom to invent inherent in a unique preschool setting.

Commenting on the phenomenon that became Modernism, Brosterman identifies the peculiar commonality overlooked by the historian:

> "Modernism," the confluence of historical, artistic, scientific, psychological, and philosophical currents that breached the banks of Western civilization after the turn of the century, has been the focus of countless investigations. Although historians have pondered the influences and effects of this cultural upheaval, particularly in the plastic arts, few have been guileless, or perhaps foolish, enough to suggest any simple reason for society's sharp turn and quick acceptance of a radical new visual paradigm at that particular point in time. Attempts at a convincing exegesis tend toward the general—democratic stability (or instability), psychosexual emancipation, the "machine age"—or the specific—Paul Cezanne's brushstrokes, say, or African sculpture. . . .
>
> But prior to their appearance upon the stage of history before World War I there would seem to be little to relate, and nothing to unite, the diverse pantheon of artists and architects mentioned above, except the obvious fact of their birth in the second half of the nineteenth century.
>
> There was, however, an international force for change of dramatic potency that never appears in discussions about the roots of modern art and is only rarely mentioned as an influence on the movement's pioneers. The Victorian childhood of the seminal modernists and their audience at large coincided with the development and widespread embrace of a radical educational system that was a catalyst in

> exploding the cultural past and restructuring the resulting intellectual panoply with a new world view. It was never fodder for argument over absinthe and Gauloises in Montmartre cafes, nor was it taught at the tradition-bound academies. It has been largely ignored because its participants—three- to seven- year-olds—were in the primary band of the scholastic spectrum. It was the seed pearl of the modern era and it was called kindergarten (pp. 6, 7).

Froebel, strongly influenced by Pestalozzi's concept of object-teaching, created tools for learning that he romantically called gifts—twenty gifts to learn with:

> . . . While these play objects—balls, blocks, sticks, paper, pencils, and clay—were not in themselves new, the integrated educational method in which they were used was, and radically so. Starting with the fundamental idea that education for the very young must begin by sensitively channeling children's constant activity and interaction with the physical world, he consciously modeled the curriculum on the natural relationship of trust between a young mother and her growing child. The gifts were toys, the teacher was the loving mother, and the schoolroom was an extension of the garden (actual gardens were also included in the original Froebelian system) (p. 35).

While Froebel believed that the child should begin formal education as early as two, he was unable to begin training children until four and five. He was further frustrated by the political machinations rising from Protestant parochialism in Germany and Jesuit arrogance in Switzerland. Had he prevailed the progression of natural learning would have been enhanced. In the present climate, where all schools are looked upon as performing a primary custodial function, this early childhood program would be viewed as an economic rather than educational blessing.

Although Froebel's approach to early childhood training predates the work of Piaget and Vygotsky, his intuitions certainly confirm their understanding that learning is constructed using artifacts. Froebel does this in an creatively stimulating and relatively unrestricted environment. Unlike the constrictive computer, his gifts are concrete and manipulative. In this context, Froebel and his vision should be received as an important pedagogical mechanism within constructionism and more than worthy of resurrection.

SUMMARY

As far as is known, humans have always had a desire to *know* and to pass that knowledge on. In spite of a physical brain that has not changed essentially in 117,000 years, its functioning element, the mind, has evolved adaptive strategies that go beyond survival. Through technological artifacts and cumulative intuitive insights mankind may have passed into Teilhard de Chardin's sphere leading to the Omega Point—union with the universe. At the very least, insights on how the brain works and how learning occurs have increased to the point where it can be said that changes in curriculum and instruction are in order, if only to meet the overt expectations of the state. Expansion of our understanding of cognition, stimulated in part be the desire to create a true artificial intelligence, is confirming the validity of the perceptivity of pioneers like Piaget, Vygotsky, and Froebel. They can serve as theoretical and practical models for change.

Chapter 5—CLASSROOM AND COMPUTER TECHNOLOGY

INTRODUCTION

It was a joint assignment to my eighth grade composition classes somewhere around 1980. On the back wall of the room large sheets of butcher paper formed a mural that showed the branching of a "make your own adventure" story tree. The individual assignment was to add one or two paragraphs to any branch of the story line as developed by previous students in their one or two paragraphs. The paragraphs could continue the story line of the branch or allow for further branching. All four classes contributed with the aid of a primitive word processor[28] on four Commodore Vic 20's. The hard copies were pasted onto the mural and connecting branches filled in with colored magic markers.

One student (I will call him Fred) was the champion troublemaker of the building. Every teacher, from kindergarten through high school remembers Fred as the scourge of scourges. He was the only student that I remember taking to the principal's office for a paddling. But, Fred taught me the power of the computer as a tool for motivating a student. When he was unsure of the spelling of a word while it was his turn to add to the story, he would send his minions to the dictionaries. He "didn't want the computer to know he couldn't spell."

If a computer could intimidate Fred where parents, policemen, principals, and teachers failed, there had to be something going on that could be tapped. What is that something? How can it be tapped? Using the computer as pawn in a tacit contract, a la *Horace's Compromise* (Sizer, 1984), does not work. One cannot con a con-artist. What did work, came from him. He realized that his work was as good as, if not better than, that of others when printed out. His ideas, no matter how wild, challenged others in the game of upmanship. His overall behavior did not change, but that is not the point here. His attitude toward some of the things done in school did change. That is the power of the computer that I saw in those early days.

Pioneers in constructionism, like Seymour Papert (1980) and Mitchel Resnick (1994), communicate a similar effect with even more powerful anecdotes. While their stories are more about student epiphanies in an understanding of concepts than of self, they are convincing. The experiences they describe, however, occur in a more controlled environment than that experienced by the ordinary classroom teacher. It is hard to duplicate the things a professor at MIT can do just by virtue of his position. It is also hard to visualize how these anecdotal events apply out of the context of mathematics; how they pertain to the larger sequences within the curriculum.

The obvious question at this point is: Where does computer technology belong in the curriculum? Especially where does *SchoolNet* fit? Colleagues on the cutting edge will answer with a resounding "Everywhere!" Other colleagues with little or no experience will give an equally vehement "Nowhere!"

The responses of the champions of technology generally suggest that, with training, the computer can be as ubiquitous in the classroom as it is in the general society. Those in opposition point out that the computer adds one more layer of unnecessary complication to an already overcrowded curriculum. Based on my experiences, nobody really has an answer to any of these questions with certainty or reliability. We are all feeling our way.

When analyzed thoughtfully most of the hype relies on past practice, but wrapped in a glitzier package. For example, the internet is touted as a place where teachers can exchange ideas. When examined, these exchanges are often in the form of lesson plans ranging from the simplistic and naive through very sophisticated activities requiring scripting in one of several hypertext authoring languages. Each has a commonality in that it seems to come complete with a set of the universal work sheet(s). As creative as many of the projects are, they are just variations of the same behavioral based activities that students see as a waste of time.

Sorting through the profusion of sources and materials is time consuming at the least; making them relevant to a particular class requires editing and revision. Teachers with minimal training in the purposes of the technology in the curriculum will view these lesson plans as the only way to use the technology. They will be pressured, through a motivation akin to guilt and spurred by innocent ignorance, to blindly follow the teachers claiming to be on the leading edge. Such reliance adds to the deskilling of teachers and the concomitant deskilling of students as well as a general fear of the technology itself.

Even with more than superficial training, will the technology fulfill the dreams of the vocal supporters whose claims have prompted the political decrees like *SchoolNet* and *SchoolNet Plus*? Any training is slow in coming. The 1996 national average of teachers with nine or more hours of technology training is 15%; Ohio ties with Oklahoma in last place with only 8% of its teachers having nine hours or more (Zehr, 1997). As in the case of summary research and statistics, there is a question of what the figures really mean. It probably can be assumed that those with hundreds of hours of self training in addition to formally recorded credentials are in that group, but there is no guarantee that this is so. Also, the figures may exclude the self trained who have no formal hours. If these numbers include the teachers grandfathered for certification in Computer Science in Ohio, they are indeed suspect. Some of those teachers had no training at all and qualified by using computers as pacifiers and flash cards. If the uncertainty of these figures are an example, the dreams of those supporting *SchoolNet* are on shaky ground.

As argued earlier, it is the nature of education that contributes to this inconsistency. Education, in its broadest form as a complex system, is leaderless and adaptation to change is usually slow. Mandates like *SchoolNet* will have an affect, but mapping a complicated technology onto the system can be expected to meet with resistance. In their analysis of this phenomenon, David Tyack and Larry Cuban (1995) describe it as part of the "grammar of schooling." Their metaphor echoes Chomsky's language organ in the brain with its built-in grammar. They suggest that there is a similar built-in structure within the system that resists and undoes reform. Unlike the Chomsky organ, however, this structure can mutate dramatically within a short time as evidenced in the histories of the development of elementary and high schools in the 19th and 20th centuries. It may be that the unexpected consequence of mandating technology will open the door to a similar massive change.

Signs that changes in the dominant educative structure are being explored is demonstrated through experiments with time allocation and spatial (plant) usage. The trimester plans in Liberty High School and several other schools in the immediate vicinity apportion class time in two hour blocks as opposed to the traditional forty or fifty minute units. Instead of a 180 day, two semester year, an English class, for example, is conducted for one trimester of 60 days. In theory, roughly the same amount of material is covered. The difference in time (120 hours vs. 150 hours)[29] is said to approximate the time wasted starting and ending classes, and traveling between classes. Furthermore, at least one school system in the area is exploring a solution to shortage of space through an all year plant-usage plan.

As pointed out before: *Ohio SchoolNet* ". . . calls for the wiring of every classroom in each school building in every public school district in Ohio with at least one telecommunications connection that will allow for voice, video, and data communication ("About *Ohio SchoolNet*," 1997)." That purpose does imply a laudable emphasis on research. It also implies communication—at least at the pen-pal (e-mail) level. With *Ohio SchoolNet Plus* locked into the primary grades, those who are closest to the workplace will be the last to receive *SchoolNet* benefits, if they receive them at all. The legislative assumption seems to be that the upper grades will somehow find funds for the necessary hardware and software. *Something* will be done. As in the case of court mandated programs for the gifted and handicapped, that something will include siphoning funds and time from the rest of the curriculum.

EVOLUTION OF A SUBJECT

From the earliest days of computers in the classroom, whether desktop or main frame, the computer itself was seen as an appropriate *subject* for study. The justification falls under the rubric of *computer literacy* (Brown, 1993). Teachers who saw value in the early technology generally tended to be math or science oriented. The subject was offered as either an elective within the math department or as an adjunct to the regular classroom.

Since the best way to learn how something works is *to make it work from the inside*, programming classes were created with the idea that programming was the avenue to literacy. In the early days at Liberty High School, the class was a math elective that used the dialect of FORTRAN (WATFIV) adopted by Youngstown State University. Students would keypunch their coding on IBM cards at the school; Mr. Shellenbarger would then personally transport the batches of cards to the University to run them on their main frame. The printouts would be transported back to the high school for correction or grading.

When the first Apple computers were purchased, the computer language students used was changed to Apple's dialect of Microsoft's BASIC (*Applesoft*) giving them the luxury of immediate feedback while they were programming. This change also allows the learning objective to shift subtly from the use of the computer for programming to a learning objective of *how to think* using the computer in a new way. BASIC proved to be a simple but effective way to do this. Rather than the strictly mathematics oriented drill and practice approach that is imposed by FORTRAN, *Applesoft* BASIC invited another level of problem solving through objects. In this case, the objects were the creation of colored graphics as a practical method to *apply* math and logic principles. The two objectives, developing thinking skill and applying math principles, merge.

Meanwhile, *word processors* were evolving from the editing programs developed to ease the primitive and cumbersome limitations found in the early versions of computer languages. The early forms of these word processors (e.g., *WordStar*) required the user to imbed (within the text) printer formatting *commands* through an arcane sub-language of keystrokes (e.g., Alfieri, 1984). Users also had to learn the techniques of file manipulation as controlled by the operating system (e.g., CP/M for *WordStar*). Because of this heavy reliance on programming and file manipulation skills in these early software packages, teachers were daunted by the learning time necessary to invest before introducing the applications into their classes. When these limitations were mostly eliminated and the software became more transparent (pioneered by software created for the *Macintosh*), curricular emphasis shifted to include computer applications.

If the content of Computer Applications could remain static in the same sense as the contents of English Composition or Geography are static, the new subject could be appended easily to the existing curriculum. However, the state of equilibrium enjoyed by traditional disciplines cannot be replicated in the areas covered by technology. Technology is in a dynamic continuum in flux. This fluidity is occurring simultaneously and interrelatedly in the areas of software and hardware.

Software

With the advent of the *integrated* software package, the change in the learning objective shifts from machine as object to the *use* of the machine or the *software* as something to be learned. *AppleWorks*, for example, expanded computer literacy in my classroom to include the relationships among word processing, data base, and spreadsheet activities. At the same time, a parallel increase in memory capacity introduced the ability to add graphics (drawings and pictures), sound, and movies (video) to combine *with* text or to be imbedded *within* the text. These extensions explode the accepted limits of the meaning of *text* as a medium for communication or record into a state requiring the creation of a concept that goes beyond the limits of current vocabulary. Terms like *hypertext* and *multimedia* are used but are weak and inadequate when trying to explain or describe the expanded concept.

It is the combinatorial explosion of software complexity imposed by the publishers that the schools find most difficult to accommodate. The scenario that makes software troublesome is imbedded in the competitive nature of the software marketplace. After a new product is introduced, it is revised periodically. Sometimes, these revisions are minor—making a particular feature smoother or adding a minor innovation. Other times, the changes are sweeping and the product is almost a new piece of software.

Even the genre of the software does not stay static. Annually, successors to the early integrated and dedicated software are published and expanded to the point where programming skills (now called scripting) are again required for the many hypertext/multimedia activities appearing in schools. Software packages, such as *Microsoft Works* (word processing) and *PageMaker* (desk top publishing), include internal linkages to graphics, sound and video, but they now go beyond and, through *HyperText Markup Language* (HTML) capabilities, allow for the creation of web pages and linkages on and within the internet. Each change or addition makes the package more desirable to purchasers, but the changes can cause problems to early users, especially educators.

Usually, older files created on an early version will convert easily to an newer version (e.g., from *PageMaker 2.0* to version 4.0) However, files created on the later versions cannot be read by the early version (e.g., *Pagemaker 2.0* finds files created on *PageMaker 4.0* incomprehensible) As the revisions become more extensive or the product changes publishers, the problems compound. Adobe bought *Aldus Pagemaker* and altered most of the program to make it compatible with its product line (*PhotoShop*, *Premier*, etc.) Now, *Adobe PageMaker 6.5* does not correctly read *Aldus PageMaker 4.0*. To upgrade files for one of my colleagues who had created her *PageMaker* documents on version 4.0, I had to convert them to version 5.0, then to version 6.5 before she could get a hard copy that resembled her original files.

Another dimension is added when the line between data base and spreadsheet is blurred. Often, one format will serve as well as the other. The lines become less distinct as more word processing programs allow for the creation of simple data bases or spread sheets without the need for a separate module. Rudimentary knowledge of data structures and file transfer or merging is essential to success in executing these programs. The essential nature of these skills is demonstrated when it is pointed out that fruitful research on the internet itself is only through exploiting strategies that employ these same skills. Those basic skills will continue to be necessary until such time as the implementation of a personalized search engine or *agent* is fully developed. In the meantime, even the idea of *computer* is changing as the technology merges computer and internet with cable and satellite television. At the same time, data structures and file transfer methods are also being metamorphosed.

Hardware

The platform on which the software is executed is a further complication with which teachers must struggle. There are two major microcomputer systems that are used in the schools: the IBM family and the Apple family. Sherry Turkle (1995) points out that the differences are aesthetic and fall into two philosophic camps: modernism (IBM) and postmodernism (Apple):

> The IBM system invited you to enjoy the global complexity it offered, but promised access to its local simplicity. The Macintosh told you to enjoy the global complexity and forget about everything else. Some people found this liberating, others terrifying. For some, it was also alarming that Macintosh users tended to dispense with their manuals and learn about their systems by playing around.
>
> Thus, by the late 1980s, the culture of personal computing found itself becoming practically two cultures, divided by allegiance to computing systems. There was IBM reductionism vs. Macintosh simulation and surface: an icon of the modernist technological utopia vs. an icon of postmodern reverie. For years, avid loyalists on both sides fought private and not-so-private battles over which vision of computing was "best."
>
> The notion that there must be a best system was of course much too simple. When people experienced the Macintosh as best, this was usually because to them it felt like a thinking environment that fit. Some expressed the idea that the simulations that make up the Macintosh's desk top interface felt like a "transparent" access to functionality. Some said the machine felt like a reassuring appliance: "It's like a toaster," said one enthusiast. "It respects my 'Don't look at me, I can't cope' attitude toward technology." Some enjoyed the feeling that they could turn away from rules and commands and get to know this computer through tinkering and playful experimentation (p.36).

With the advent of Micrsoft's *Windows 95* as the operating system for the IBM family, the distinction has blurred to the point of irrelevancy: Microsoft elected to copy the Macintosh operating environment. In the meantime, Macintosh provided cross platform capabilities by simulating the IBM environment or providing translator software within its operating system, thus eliminating the barriers to easy exchanges of data between the systems. In addition, translators are incorporated in third party software. Students often bring files created at home on their IBM clones and use the Macintoshes in the high school's lab to complete a project or to make hard copies of it on the lab's laser printers.

The question of platform compatibility and the software up-grading process described earlier are not the only impediments to a consistent use of the computer either as a subject or as an implement for use in the classroom. An *up-grading* augmentation, parallel to software change, occurs in hardware (e.g., by increasing memory capacity, adding CD-ROM capability, and providing internal modem and *ethernet* functions) Changes are also made within the operating system software, adding yet another layer of potential hardware incompatibility. Of themselves the changes in hardware (as with software changes) are laudable. But, as in the case of software packages, it is not unusual to have several generations of a given platform as well as several different platforms available to teachers within a school system.

This combinatorial explosion of hardware complexity imposed by manufacturers, coupled with school purchasing practices, present an *archival* problem for the teacher. Any classroom materials developed at one point in time, may not be retrievable at a later point. I have several hundred disks of such material which cannot be reproduced directly by the hardware in my classroom. These volumes, representing unknown hours of labor, are essentially useless. To recover any of this material, it will be necessary to resurrect obsolete computers and printers to make hard copies for scanning into files created by current software. In ten years the electronic version of this paper will be unretrievable.

CATCHING THE WAVE

The structure of the majority of classrooms has not changed in any appreciable fashion for the past century or more (Papert, 1993). In fact the central focus in the classroom, the teacher, has not altered in centuries. Reformers are trying with approaches that make the teacher a *guide on the side*. For the majority of teachers already in the field, however, these efforts are not founded in an understanding of the interpersonal and intrapersonal nature of the cognitive processes and lack the depth in training necessary for a true change in that direction. The belief that the child is a little adult that only needs to grow up is too strong and only adds to the misunderstanding of how the child constructs knowledge. By third grade it contributes to the loss of *trust* in the guide on the side.

The addition of technology by fiat to the school does provide an opportunity for significant change. However, the change is like the surfer trying to capture a wave at the beach. Timing and training must conjoin if there is to be any degree of success. The legislation in *SchoolNet* provides funds for technology training. But, the training programs that I have seen assume that knowing how to use hardware or software (computer literacy) is sufficient for any kind of meaningful translation to the general classroom. Creating fancy multiple choice worksheets or developing glitzy multimedia lectures do nothing to change the pedagogical errors generated by past practice. Computer literacy is vital, but so is instructional literacy. The timing of both forms of training must conjoin if there is to be any degree of success.

A comprehensive model for uses of technology that are oriented toward a constructionist pedagogy does exist. Begun by Apple Computer Company in 1985, it is an ongoing experiment. The project demonstrates the complexity that technology introduces to schools. A summary description to date is made in *Teaching with Technology* (Sandholtz, Ringstaff, and Dwyer, 1997).

Called the *Apple Classroom of Tomorrow* (ACOT), the project is true to constructionist philosophy by allowing growth and change in teachers and students to occur naturally. In the beginning little was done to drive the project beyond the influx of technology:

> Although ACOT staff provided training and support for teachers in response to their expressed needs, the early stages of the project operated in the mode of a laissez-faire experiment. ACOT staff did not try to hold variables constant to test theories. Instead, they supported a generative model, encouraging variation and change. Rather than imposing an agenda, the staff let events unfold and evolve. The initial guiding question of the research was simply put: What happens when teachers and students have constant access to technology? No attempts were made at this point to promote pedagogical change as teachers and students adjusted to these high-technology classrooms.
>
> To investigate the impact of technology on project classrooms, ACOT sponsored research involving more than 20 universities and research institutions. For example, some researchers examined student writing, students' thought processes, and student empowerment in ACOT settings. Others developed technological learning tools to enhance understanding of subject areas such as physics and calculus (p. 7).

Initially teachers attempted to follow their past practices. Like the teachers that I interviewed last summer, they " . . . successfully translated a text-dominated, lecture-recitation-seat work instructional approach to an electronic medium (p. 9). But, this did not last:

> As the project progressed, changes in classrooms became striking. Teachers began teaming and working across the disciplines. Administrators and teachers modified school schedules to accommodate unusually ambitious class projects. In addition, teachers and students began demonstrating mastery of technology, frequently integrating several kinds of media in their lessons or projects. ACOT classrooms became an interesting mix of the traditional and nontraditional.

> Teachers experimented with new types of tasks for students. In addition to becoming comfortable with new patterns of collegial interaction, they also encouraged far more collaboration among their students. In most instances, teachers altered the physical setup of their classrooms and modified daily schedules to permit students more time to work on projects. They also provided more opportunities for students to use a broader mix of learning and communication tools. Finally, teachers struggled with the need for new methods of evaluation that could capture the novel ways that students were demonstrating their mastery of skills and concepts. At most sites experimentation with performance- and portfolio-based assessment began (pp. 9-10).

Anyone who has used the internet for research soon finds that the reliability of some of the data is tenuous. Much of what is found can be corrupted or lacks authority. There are too many sites that are created by twelve year olds or crackpot *authorities*. While I have used the Net to prepare this paper, I have relied upon it almost exclusively as a pointer rather than as a source. This idea, that the internet can be unreliable, suggests that the evaluative process of electronic work constructed by students should include a higher standard of scrutiny. ACOT researchers share this concern as they warn:

> The knowledge-building activities of students must not end with privately held constructions. Students' paraphrases, new ideas, models, drawings, and compositions need to be shared in a critical light. They need to be reviewed by peers, explained to parents, presented to expert panels, considered for entry into personal portfolios, and reviewed and assessed against rigorous standards. The process allows the discovery and correction of misconceptions while it gives purpose to learning tasks. Students need a sense that their work is important, that what they do matters, that other people will be interested in and care about what

they discover. Sharing personal knowledge raises the stakes in classrooms. It introduces a sense of risk that makes students inquire more carefully and deeply (p. 13).

BEYOND TODAY'S TECHNOLOGY

One of the primary driving forces of technology development is the contemporary desire to create an artificial intelligence. That quest may prove to be as fruitless as the goals of the Alchemists were in medieval times. Whether a breakthrough does or does not occur, the cognitive sciences will have ripened and education will be the better for the effort. The cognitive sciences will be awesome, for we will then know as much about the brain as we now do about the composition of hydrogen and the energies in atoms.

There is one vibration from research and development that may prove troublesome. Echoing the early days of film in the schools, the entertainment industry seems to be moving into publication for the lucrative education market. A new form of electronic textbook [???] dubbed *edutainment* is appearing in the marketplace (Shenk, 1997b). The seriousness of this hybridization of education and entertainment is underscored when it is announced that Seymour Papert, Marvin Minsky, Alan Kay, and other luminaries of the education and artificial intelligence communities have joined the Disney Corporation as advisors (e.g., Ouelette, 1997). Coupled with the kind of commercialization evidenced by *Channel I*, further commercial ties might be expected as communities abrogate their role in the school in their efforts to seek tax relief.

SUMMARY

I have repeatedly pointed out that imperfect concepts of human learning reign in education. These understandings have been examined from a variety of perspectives. They reside within a framework of cognitive illusion. The dominant cognitive illusion that abstract human activities—thoughts, ideas, knowledge, learning—can be measured supplants the purpose of schooling, the very things that a supposedly measured. The view that the brain is a mechanical device where learning can be programmed in a linear fashion, like a computer, is so strongly imbedded in the school culture that educators see the politically mandated influx of technology as *the* answer to "preparing students for the 21st century."

The cognitive illusion framework is attempting to mold the insertion of technology into curriculum and instruction within the prevailing concept of learning. The vibrant nature of the technology causes discordance as the software and hardware metamorphose. Unlike the attempts to incorporate radio and television into the school, any attempt to *fix* technology either as a subject or as an adjunct to existing subjects must fail for this reason.

The ACOT project provides a beacon that can serve as an enlightened direction. But that beacon is extremely expensive and depends heavily on knowledgeable auxiliary support to the classroom teacher. It demonstrates, however, that the power of the cognitive illusion can be broken; that the classroom tends toward the natural construction of knowledge when not impeded by constrictive ideology, populist posturing, and inadequate funding.

CHAPTER 6—BUILDING A SEAMLESS SCHOOL

INTRODUCTION

The hall was a little over three quarters filled. Waving a book over her head and with the zeal of any evangelist, the speaker fervently extolled the audience to abandon wrongful practices and return to the book of "our fathers." Her admonishments were delivered with a mixture of brimstone and ridicule. In a brief respite, a soloist sang a hymn that she had composed for use in local revivals. In the hymn, she earnestly sought release from the temptations of worldly evil forces.

When the moderator of the gathering called upon the faithful to give testimony to the *Truth*, two long lines of the devout formed in the aisles. Among these were a Youngstown State University Ph.D., a mechanic, a housewife, a budding politician, and a student—the common and the not so common. All affirmed their belief in good over evil. All emotionally confessed their experiences with the good path and decried the presence of the evil ways being brought into their community.

The meeting was held in the high school auditorium in the moderate to high income community, Canfield, Ohio. The book of "our fathers" was the *McGuffey Reader*; the good path: phonics; the evil: whole language. The speaker was brought in from Texas by a fundamentalist group seeking to exorcise whole language from the curriculum. The moderator was a former disk jockey turned talk-show host who had asked the soloist to *inspire* the attendees. The meeting itself was the result of a very vocal campaign initiated by one parent because his third grade daughter was not reading at a sixth grade level. The handful of us (concerned citizens and taxpayers) who sought moderation were booed as we tried to speak.

That picture, within its surreal frame, demonstrates the wide gap that exists between those who would maintain a traditional one-way-fits-all curriculum and those who would recognize diversity. The phonics and whole language debate is not the point here. A larger question is raised by the clash. How does a rapidly changing, technology rich, extensively diverse society adjust if its schools are forced to conform to a sectarianism that identifies outmoded pedagogy with traditional moral values? The black and white, all-not-all, of the argument adds to the absurdity. The hungry mob wishes to destroy the bakeries on moral grounds.

The standard of what is basic in the curriculum has changed over the years. In my elementary school, math focused on the traditional basics of addition, subtraction, multiplication, and division. To be considered proficient in addition one had to be able to accurately add columns of fourteen numbers ranging in length from three to nine digits. In later grades, we were required to manually find the square root of any given number. These were the skills needed to be a salesman or an engineer at that time. The addition skill was for those who would end their education in the sixth or eighth grade with the hope of *getting into trade*. The higher skill was for those who might be lucky enough to go to high school and perhaps to college. Even the most ardent back-to-basics advocate would hardly desire a return to that period, even if it were possible.

In spite of the belief that the purpose for schools and the economy should be divorced, they cannot be. The twofold purpose served by my elementary school curriculum reflected the needs and realities of the economy. Even though my time in school was a period mostly within the depression years, the curriculum was based on an era when jobs were not scarce and most jobs required a minimum of skill. It was a period during which an immigrant could easily find employment without an elementary skill in English. It was a period when an individual could leave school and expect to be employed almost immediately. It was a period in which an individual could continue in school and even go to college, if the family could afford it. When attendance in high school became mandatory and, later, when the GI Bill allowed almost free access to college, the stay in school lengthened for most. However, by the end of the depression and into the 60s, the ability to get a job with or without a high school diploma was not a serious problem for most individuals.

But the realities of the economy in the later half of the 20th century have changed dramatically. Part of that reality is the nature of the job market itself. Within that short period of time the economy metamorphosed rapidly. From a heavy industrial base it passed through a *niche service* stage, followed rapidly through an *information age* to a *communication age*, and is now in a period of a growing *electronic consumerism.*

With the advances made in computer related technologies and the integration of the U. S. economy into a world economy, a new attitude is needed toward curricular content and instructional theory that prepares students for more than an economy. In addition to an understanding of current data structures and other prevailing computer related knowledge, *the new curriculum must prepare students to adjust to change*—change within the technology, within the economy, and within the society itself. Doing this will require an abandonment of the positivist faith in a one of anything fits all. Doing this will require an abandonment of a faith in any master *Theory.* This new attitude is relativist (pragmatic or eclectic if you insist) and goes in the face of some popular dogma.

In this Chapter, I wish to draw together the theory that is implicit in the previous chapters. This is not the Theory; it is a theory; it is not intended to be a pedant's panacea. To make the concept more concrete, I will describe a seamless system that is based on four principles that are the unifying factors found in the previous chapters:

- all individuals have an inherent desire to know;
- development occurs best through and in a participatory environment;
- development passes through three stages (novice, apprentice, and expert); and,
- development and learning are best constructed by the learner.

It is based on the idea that education is an adaptive complex system with an apparent coherence—like Resnick's flock of birds. Its structure has shape, but when the winds of change require a rapid turn in direction, it must be prepared to adapt immediately. As with the flock's banking and turning, the veering must be graceful and without confusion.

THE VISION STATEMENT

Most school related vision statements will include some reference to learning or knowing. In the sense that the school has the obligation to assist the child in learning, I agree. Assistance is the *job* of the school. It is the mechanical part assigned by the society. I argue, however, that learning, a process, is a *survival* function within the child. It is a vital function parallel to eating. Instead of fueling the metabolism, learning fuels whatever part of us that separates us from other animals.

Aristotle tells us that we have a need to know. His *knowing* contains the ideas of growth and development as well as the specifics of knowing facts about sea urchins. It is when learning is translated into a catechism of facts (in the vision statement) that the vision is trivialized.

The school was created as a device to perpetuate the institutions of the creating society. Since the school is a social construct, it is political in nature and reflects the economic needs of the society. Denial of its origins through an esoteric or arcane jargon does nothing to advance its purpose and, especially, its vision of that purpose. Therefore, the vision of a school should express a social purpose. In a democracy, that purpose should embrace all citizens. The execution of that purpose should be tailored to the needs of the individual as far as is practical.

My vision is not original and reads:

> All citizens must be empowered
>
> to earn a living
>
> to enjoy a quality leisure, and
>
> to execute their duties of citizenship
>
> in a global community in which change is
>
> inevitable,
>
> continuous, and
>
> unpredictable.

That statement has two parts. In the first part, empowerment is achieved through learning and an unfettered access to ideas. It envisions that that empowerment is achieved through a curriculum that is, for the most part, traditional in content. It is a vision, however, that places language in the sense that Vygotsky uses it in primacy within the curriculum. This means that language is not just a sufficient condition for learning in any discipline, it is a necessary condition before any kind of learning above animal behavior can take place.

In *Jefferson's Children*, Leon Botstein insists that the centrality of the language-thought relationship is underestimated and occurs best through the writing process:

> The fundamental importance of writing for education derives from the centrality of language to thought. Writing ensures the active command of language. Too often, however, the connection between language and thinking has been misunderstood, leading to traditional but misguided ideas about how writing should be taught. Many of us were taught to gather our thoughts, organize them, and then

> write them down. The truth is that writing is a process that generates thought. Only when we try to write something down do we discover what we really think. Writing is not the documentation of thought already formulated. The finished thought emerges most often from a reaction to drafts of that thought in writing. Therefore, revision is a crucial skill that needs to be taught (p. 71).

The first part of the vision statement also contains the political concept of life long learning in terms of all citizens. It is a womb to tomb concept. This is political in that it uses a political definition of citizenship (all who are covered by the Constitution) to define its scope and limits of entitlement. This idea goes beyond the usual life long learning cliché that seeks to prepare students for learning beyond school as if infants somehow are not part of the continuum of life and early childhood learning can be ignored or is irrelevant.

In addition, the first part of this vision acknowledges that there is a dimension of humanity that requires nourishment. The statement is purposely ambiguous as to the nature of that nourishment, but in my thinking it is the mostly unexplored area of spirituality. The ambiguity rises more from the means of achieving it than from its nature—whether it is achieved through recreation, the arts, religion, or any combination of these. The school enhances the spiritual experience by intensifying awareness.

The second part of the vision statement defines the nature of curriculum in terms of the characteristics of change. This is also a political statement and recognizes the global nature of interdependence that is manifested through changes such as the internet. This part of the vision focuses on the practical *purpose* of education rather than on an ideological and potentially divisive *intent*. The facility to adapt (e.g., judgment) is part of the survival tool kit. It is a key element in Binet's quest to define intelligence. Competencies necessary to accomplish this are antithetical to the test taking skills that are the only assessment made in normed *proficiency* testing.

SCOPE AND SEQUENCE

By defining learning as a continuous process that begins at birth (more likely before birth) and ends with death, the formal school can only be thought of as the preparatory stage in that process. The scope of the school's role within that frame can be described in two dimensions of the sequence: the *length* and the *depth* of overt or formal training. The length can be described by the phrase "as long as it takes." That is not so different from the current practice. If an individual wishes to stop at the high school level he can; if an individual wishes to become a doctor she can go beyond the bachelor and masters levels in the university; if individuals wish to (or must, due to circumstances) delay or change academic paths, the gates are open to them. Passage from lower phases to succeeding or parallel phases are seamless.

The concept of *phase* is defined here as corresponding ambiguously to levels. This is the un-graded school concept of the 60s without the excess rigidity of an all-not-all system (Brown, 1963; Brown, 1965; Beggs & Buffie, 1967). The word *phase* is used because its connotation does not carry all the measurement baggage of *grade* or *level.* When speaking of phases, it is not easy to define where one starts and one ends. It is the *between* of grades and levels. This indeterminate quality allows students to move horizontally or vertically through the curriculum without stigma or praise. Because of the amorphic property of position within the whole, the student is not vying for an artificial numeric peg of identity. In the early phases benchmarks, of necessity, will be established by teachers. As the child develops independence, personally constructed benchmarks identify progress. That construction does have a caveat. It is recognized that even at the university level complete independence is rare. Therefore, construction of benchmarks, in practice are not completely unconstrained. In keeping with the collegiality of cooperative activities, family, peers, and teachers will assist in establishing achievable benchmarks. Learning is the end not competition.

In the following, phases are identified in terms of I, II, etc. There are also some signposts that identify a position within the current structure. These boundaries are not to be taken literally. Because of individual differences in aptitude,[30] some individuals might spend time in advanced groupings as well as less advanced groupings. In an exaggerated example, Mozart might spend his mornings with three to five year olds with Froebel's gifts, and his afternoons in the conservatory composing operas.

Phase I

Since the period up to the second year is crucial for emotional identity and bonding within the family, that time is rightly the exclusive province of the family. The exception would be in the case of poverty where the social function of the state can be employed to support (not supplant) the family. This is a period that can be likened to providing the school child with a good breakfast before attempting any learning. If the child is not nourished emotionally or socially, a breakfast in the form of readiness remediation will be necessary. It is best done within the context of the family.

The normal path of this scheme begins with neighborhood early childhood learning centers. These have a clientele of children starting at eighteen months to two years and ending roughly at what is now the end of kindergarten. These centers are the beginning of the formal cycle. The criteria of acceptance is the child's general position in the zone of proximal development. Those who fail to qualify would be given a flexible individual plan[31] for advancement that would be in effect until the child reached an appropriate developmental zone, at which time she could enter the main stream.

These centers, as with all stages of the scheme from the learning center through the university, are ungraded. The population of each group are multiaged and at differing stages of cognitive development. Since one of the goals (implied in the vision statement) is to begin cooperative socialization as early as possible, advanced peers (not necessarily older children) will assist the less advanced. The multiaged composition of the group has the added advantage of building in behavior modeling rather than behavior by rules.

As pointed out in Chapter 4, Piaget, Vygotsky, and Froebel share a common sense of human learning, although they do describe it using differing terms. One mutual point of view is summarized by the term communication tools. These are the *objects of learning* and are the core of the school's scope and sequence. Objects of learning are abstract (language, ideas) and concrete (toys, books, computers). Of the three pioneers, Froebel relied mostly on the concrete when he demonstrated, through his gifts, how the child could learn by constructing creative experiences. The genesis of the idea was not totally his. Pestalozzi, his mentor, introduced him to the concept that learning is through objects. Later, Maria Montessori (Montessori, 1914/1965) and John Dewey (Mayhew and Edwards, 1935/1966) also created environments or laboratories of learning where objects were used in exploration and as tools for cognitive growth. We now see the practice downsized in the name of efficiency and economy into the sterile manipulatives currently in use.

Froebel took the objects beyond the frame of mere experiential *things*. The first gift, six soft crocheted balls with tails—each a different rainbow color, was used to teach more than just plasticity, colors and motion. A description of how that gift was used will serve to give the flavor of Froebel's intent for each of the gifts:

> By grasping, rolling, dropping, hiding, and swinging the ball, the child gained intuitive and experiential knowledge of object, space, time, color, movement, attraction, union, independence, and gravity. Nuts and berries were natural balls, as were the seed pods of the dandelion and sycamore and the sun and the moon. Eggs and cabbages and eyes and heads were balls, and the good kindergartner could lead

> her children through the realm of nature with only a ball. In play, it might become a bird as it flew, a cat as it sprang, a dog jumping over a hedge, or indeed any one of a million other everyday events in the life of a child. Mathematically, it was a point and the number one. Together, the six balls represented the realm of knowledge in the form of a line for counting and a set for learning addition and subtraction and the beginning of multiplication and division. In the realm of beauty, the balls together encompassed the primary colors—red, blue, and yellow—and the synthesis of their unions—violet, green, and orange (Brosterman, 1997, p.42).

The mixture of real experiences and play experiences described here were originally intended, by Froebel, to begin with the infant. In the seamless school scheme, the child's beginning follows his original intention. The power of a uniform *early* start for all cannot be underestimated.

The scope and sequence of the curriculum for this scheme begins in this humble fashion. It begins where the child *is*, not arbitrarily at some artificial point. Piaget tells us that there is a sequence to learning. He tells us that the stages cannot be forced, nor can they be bypassed (Ginsberg et al, 1969). I begin at these early ages for that reason. It is also for that reason that the child is not ready for the computer as an object for learning. If the child is to be ready to use the computer, the child must have a repertoire of human experiences sufficient to overcome the conflicting anthropomorphic attributes assigned to the computer through software.

I also suspect that by placing computers in this milieu there will be a reinforcement of the distorted experiences the child has through the wide practice of using the television as a baby-sitter in infancy. Use of computers too early in the developmental process might have the unexpected consequence of creating a human reality in which there are two worlds: one flat and two dimensional, the other rich and three dimensional. A holotropic virtual reality of the Star Trec holodeck variety (Murray, 1997) is not with us yet.[32]

The Other Phases

The keyword, *seamless,* for this school is not an accident. As the word implies, there are no breaks in the educative process. Just as the term ungraded implies that there is no first grade or second grade, there is no visible break between elementary and secondary, or secondary and college (or beyond) in a school that has as its vision adaptation to change. Terminal points or exits can occur at levels where the student can be productive in society and within the framework of laws protecting children from exploitation. Flexible re-entry points allow individuals to alter their economic or academic position.

When the child masters the initial phase of readiness, the traditional curriculum[33] of the school begins. Most importantly, the *pattern for learning* is set. A working set of communication tools is established. The child will continue constructing in the multiage groupings formed and reformed, and defined by zones of proximal development rather than *ability* or *age*. Memorization as a tool for learning is kept to a minimum. Memorizing the alphabet or multiplication tables are worthwhile time savers, but they are not substitutes for the concepts they represent. As benchmarks of mastery are achieved the child or children is/are moved into other grouping(s). By encouraging adaptation to change as a constant within groupings, the child develops behavioral strategies for coping with change. Since all children are also regrouping, the stigma of the elitism of *advanced* classes or *remediation* classes is not part of the social dynamic.

A reorientation of plant space use will be necessary because of the student's horizontal and vertical flexibility in zone movement. In some cases use of both time and space must be altered. The ideal arrangement would be a campus-like grouping of spaces (Mozart walks a few yards to the conservatory). In this ideal situation spaces (rooms, floors, wings of buildings, and buildings) are accessed without bussing. At some point students having multiple zone needs will find that one set is served in one place and others are served elsewhere. The campus grouping allows for smooth (seamless) transitions.

The ideal is not physically possible in many, if not most, cases. If the main spaces (buildings) are separated by distance, the scheduling of time for students in the transitional stages will be necessary: dividing their day into halves or thirds. Since this condition affects only a few students at a time, a solution to the transitional stage condition is suggested by the current post-secondary option in place in Ohio high schools.[34] These students are released to another building rather than being placed in unproductive custodial holding tanks.

Museums For Learning

Imagine a large space in a school, about the size of a good university gymnasium. A diorama defines the limits of the room. It depicts the skies and distant mesas of the Southwest. This is the backdrop for a realistic setting—not unlike a movie set. In the center there is a pueblo village complete with Kiva. Ladders lead to the second stories of the buildings. Authentic artifacts (bowls, native dress, ceremonial shields) are scattered about: resting on rocks or on the imitation ground, hanging on walls of the pueblo, or tied to crude pole structures. For the next six or eight weeks this is the main classroom for some forty or fifty students. It has been erected for their use as they explore the district's common unit theme for the year—*form*. The students range widely in age and interests. They are divided into groups that roughly approximate academic need and interest. Two groups are from the performing arts wing: One explores Hopi dance forms; the other explores form through music and song. Another group is from the computer center: They prepare CAD analyses of the architectural form. Another group explores form through color. Another explores the limits that nature placed on the form of mathematics.

This classroom travels from school to school and is maintained by the state. It has been erected by state employees who are part of an army serving the schools with *museums for learning*. This is one of the largest. In the school complex there are two others: a sub-atomic physics lab (scheduled for three weeks), and a sculptor conducting master classes (scheduled for two weeks). Wherever necessary (as in the case of the pueblo mockup) ancillary materials (a library, CD-ROM and laser discs, listings of web sites) accompany the exhibit.

Howard Gardner advocates museums or exploratoriums for children to learn in (e.g., pp. 112-13 this paper). The idea is a supportive insight into the concept that children learn best with the objects of their learning. I would suggest that, instead of field trips to museums, the museums are brought to the school and left for children to explore in depth and in leisure. Just as a one day workshop is not effective for teachers except as exposure, a one day field trip for children is not much more than a break in monotony.

The idea is not new—only the scale. Artifacts from a variety of cultures supplied by the natural history museum in Boston were part of my classroom environment in the primary grades in Quincy (MA). Bulletin board display materials, in the form of mounted pictures and sealed swatches of fragile materials not intended for little hands, rounded out the package. Footwear from Japan, Holland, and Russia expands the concept of *shoe*. Feeling the texture of the dolls, the pottery, and scarabs of antique Egypt—not just fleetingly as in a museum field trip, but daily and at leisure—establishes a permanent connection with the past. However, the size and quantity of artifacts was confined to an easily transportable box, limiting the size of the tactile experience. And, not all schools are fortunate enough to be near centers like Boston (even for field trips). To overcome the limitations of field trips or the expenses of district ownership of expensive and infrequently used objects, the state sponsored traveling museum expands the idea of technology in schools.

The initial cost of outfitting a van load of scientific or cultural artifacts need not be born by the state. Foundation grants, private and corporate, can provide the seed money and *quality control* to ensure equity and success. The energy poured into redundant research projects (e.g., class size) would be better spent designing significant exhibits.

Assessment

By its very nature, the school in this scheme is a challenge for those who insist that all things are measurable. To state that the gap between objective and subjective judgments appears to be wide, seems to be stating the obvious. However, I suggest that results of objective testing do not reflect the certainty professed by its advocates. Factors such as memory degradation and corruption, transference of learning by association, and methods or means of exposure play strong roles in the learning processes and are not measurable through paper tests. When considered within a broader context, both objective and subjective evaluations appear to coincide (as when comprehensive criteria are used in student evaluation). In such a state, subjective judgments are superior because the individual(s) making the evaluation can adjust judgment to the circumstances in effect at the time of assessment. The objective test removes the human ability to reconcile and responds in a mechanical way that ignores the between of qualifying factors.

The problem for the teacher is not unlike the grading of paintings in art. An expert does know the differences between levels of quality in terms of composition, color, and technique. A fourth factor, *taste*, influences the equation, but that influence, when combined with the other factors does not result in an all-not-all condition. Children learn the frustration and unfairness of objective testing early in their careers. This may be one ingredient in the equation that explains why children are turned off to education by the third grade.

In addition to the perception of inequity through scores as a device for sorting, the inordinate emphasis on competition and accountability invites moral decay. Cheating, whether by the student or the principal, is the inevitable recourse in any such all-not-all circumstance. The unfairness of the trickery implicit in the construction of multiple choice questions, for example, undermines trust in the fairness of those in power—those who do the sorting and judge for accountability. The child learns to trust the parent—the care-giver, the one in power. That trust is betrayed in the sorting processes of the school. Once trust is undermined it is next to impossible to restore (Fukuyama, 1995).

The Scheme In Plan View

When a cartoonist depicts a school, the typical sketch shows a small bell tower on the roof of a simple building. For a period of about two hundred years the bell tower was incorporated in most urban and rural schools and only went out of favor around the early part of this century. It would require some effort to find a building with a real bell tower today outside the context of historical preservation (e.g., Gulliford, 1984) or as a symbolic architectural appendage.[35] The image comes from our early history when a congregation would build a new church and turn the old one over to the community for use as a school. Those early buildings reflected the nature of the society at the time, since church, community, and school were not too widely separated. The bell that called the faithful to worship could be used to notify all that school was in session.

Little modification was necessary to change these small churches into schools. The vestibule was used as entry and cloak room; the altar dais was used for the teacher's desk; and, within the space of what had been the body of the church, the students performed the rituals of learning. A pattern was established. The architecture of schools in America was conceived as a hand-me-down and that concept continues to haunt the design of most schools. It persists through the ways in which new school construction is funded, architects are chosen, and the interiors are organized.

The complaint that funding and architects are inadequate is not unique to the present. In his book on *modern* schools, Warren Briggs (1899), a consulting architect and recognized authority on school construction of his time, decried the funding, charging that: "One of the primary causes of unsatisfactory buildings is the lack of sufficient funds to properly erect and fully equip structures of the required size (p. 21). He goes on to point out the inferiority of contemporary architects:

> The almost universal method of obtaining designs for schools or other public buildings cannot be too strongly condemned. I refer to the unrestricted or open competition. No surer way can be devised to prevent the first men of the profession from submitting designs than this; therefore the primary object of the competition, which is to obtain the best talent, is defeated at the very outset by the course ordinarily pursued (p. 33).

Today the inadequacy of funds and the unrealistic expectations of the voter limit the architect more than an inadequacy of training or creativity.

The plant is the physical reflection of the philosophical relationship between curriculum and instruction. In the colonial period, carrying over from the medieval model, the classroom reflected the ecclesiastical influences of the monastic Chapter House which was essentially a long narrow room with the abbot (teacher) on a dais at the end opposite the entry and the monks (students) on benches along the long walls facing each other. Later, when industrialization dominated the economy, the shape of the school building imitated the shape of factories and warehouses. Although the student moved from the sides of the room to the center, the relative position of the teacher to the student did not change.

After Taylorism gained strength in the school culture, the interior of the building was molded by the efficiency of scientific management that dictated a place for everything and everything in its place. While the relationships of the inhabitants of the classroom did not change, the uses and locations of classrooms reflected the linearity of the philosophy: assembly line learning.

As long as the majority of graduates were considered the raw assets of industry, the expectations could be low. The desirable skills in a Taylor factory were punctuality and the ability to perform simple rote tasks over long periods. The school became so successful in this that it finds it impossible to adapt to the needs of a new economic reality.

In his study of "how exceptional companies bring about their own downfall," Danny Miller (1990) labels the similar phenomenon in business *The Icarus Paradox.* Like Icarus who succeeded in flying so high and so well that the wax of his wings melted, plunging him into the sea and death, companies can also be too successful, and in that success, fail. The summary description of Miller's thesis applies to schools as well as to business:

> It is ironic that many of the most dramatically successful organizations are so prone to failure. The histories of outstanding companies demonstrate this time and time again. In fact, it appears that when taken to excess the very factors that drive success—focused tried-and-true strategies, confident leadership, galvanized corporate cultures, and especially the interplay among all these things—can also cause decline. Robust, superior organizations evolve into flawed purebreds; they move from rich character to exaggerated caricature as all subtlety, all nuance, is gradually lost (p. 3).

As with the all businesses suffering from being too successful, the school is operating under the cognitive illusion that past successes will carry the day in any crisis.

Moving from "rich character to exaggerated caricature," teachers have a persistent belief that past practice is the best practice. This persistence is best demonstrated in the uses of space and the tenacity with which teachers hold to the concept of *classroom.* It is a notion that is derived from the teacher centered character of space use, whether Chapter House, Dame School, or the assembly line model. The concept contains more than the material perceptions of ownership and territory. More importantly, it includes the element of identity within the culture. The teacher without his classroom is viewed as a transient—a homeless person; a bag lady. Without a classroom where does the teacher put her *stuff*?

In a school that has adaptability as a goal, the use of space is expected to reflect the same flexibility found in the groupings of students. Figure 14. is a skeletal floor plan of a possible allocation of areas intended for this scheme. Versatility is imbedded into the program.

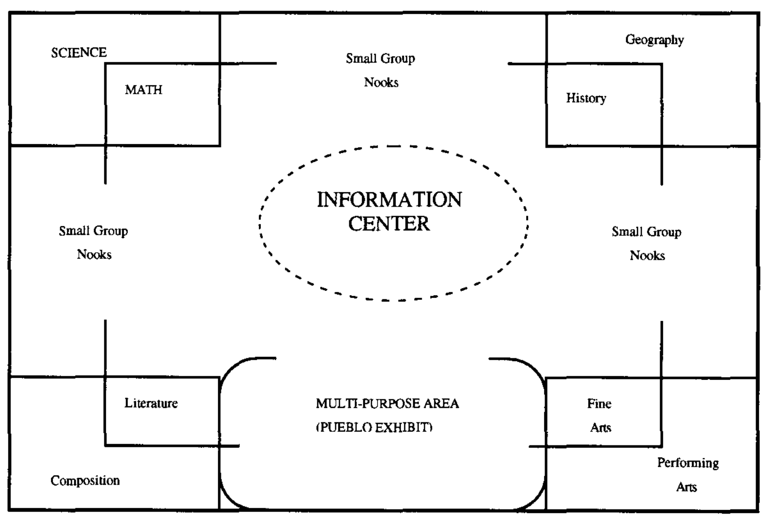

Figure 14. A seamless school in plan view.

The concept of this floor plan is directly derived from the vision statement. It is driven by the belief that empowerment is achieved through learning and an unfettered access to ideas. The physical source of this empowerment is the *Information Center.* This is the true center of the school. Unlike such conceptions as library, media center, or resource center, the information center is not an adjunct to the school. *It is the school.* Subsumed in this concept are the areas of specialty that need dedicated spaces for the communication tools that enhance the educative processes. These satellite spaces are enclosed to ensure safety (e.g., science), reduce distractions (e.g., audio/visual demonstrations), or provide a controlled ambiance (e.g., ecological habitat).

The idea of a *library centered school* is not new. The medieval church university had its Scriptorium (where books were copied and stored) near the Chapter House. In practice, however, the library in today's school is anything but the center of the educative process. The visiting public sees the trappings of *library* but the operation is subtly obfuscated. Bowing to the custodial functions of schools, the library in most secondary schools has degenerated to a dumping ground for study hall overflow, monitored by low paid aides. Media centers, the nominal successors of libraries, added the function of economical clerical distribution centers for VCR's and overhead projectors—two purposes served for the price of one. Neither purpose furthers the needs of the school nor the needs of its clients.

Beyond the commonalties of skills in communication and interpersonal relationships that are vital in the workplace, the majority of individuals must be schooled in the techniques necessary for information retrieval, assimilation, and propagation. These abilities are crucial to advancement in higher education as well as survival in the workplace. They are skills that must be cultivated with deliberate and concentrated shaping throughout schooling, beginning shortly after Phase I. The focus shifts from *teaching* nominal thinking to a conscious application of cognitive constructions. The Information Center is the practical laboratory wherein students construct that learning.

The philosophy of adaptability and its physical embodiment as modeled in Figure 14. is used as the archetype for the comprehensive plan of the scheme itself. The master plan envisions nested phases as well as overlapping phases. A second skeletal plan is necessary to illustrate the overall structure and relationships within the scope of this scheme (Figure 15.).

The Mastering Scheme

With the general image of Figure 14. in mind, there are four major campus clusters, each with a differing *mastering* focus or orientation:

- the *neighborhood learning center campus* (discussed above as Phase I with an elementary school component and spaces for basic adult learning);
- the *community campus school* (comparable to the local district elementary, middle, high school, and junior college, and spaces for relevant adult learning);

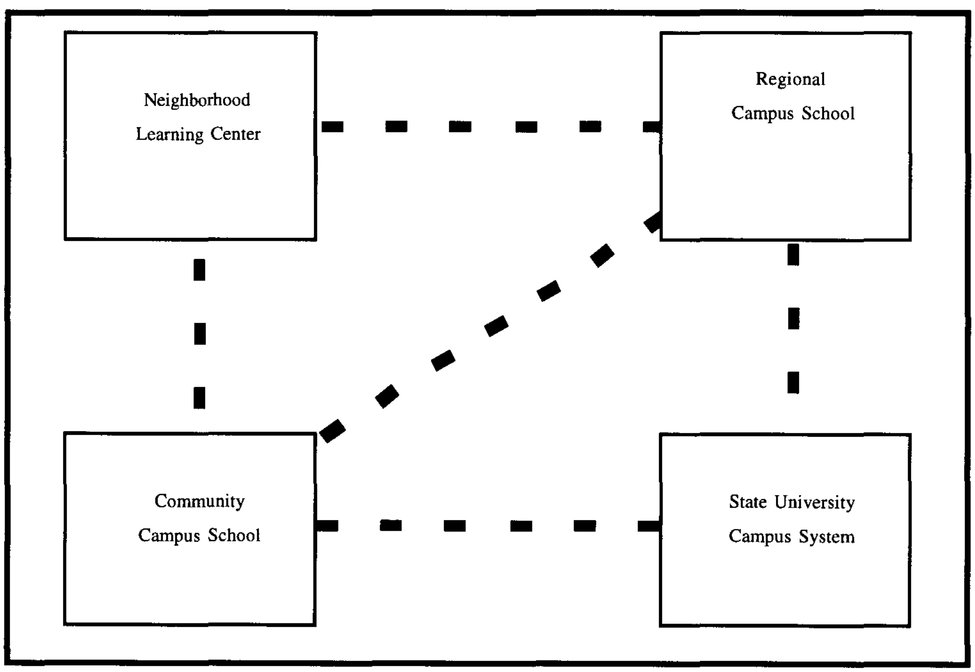

Figure 15. The total seamless school system.

- the *regional campus school* (comparable to a county magnet school specializing in fine and performing arts, and, science and technology at the junior and senior high school, and college levels, and spaces for related adult learning);
- and, a *state university campus system* (colleges of medicine, law, science, humanities, and spaces for advanced adult learning)

Because of the overlapping interconnectivity of curriculum, transfer from one mastering orientation to another can be seamless. In Figure 15. this interconnectivity is shown by the dark broken lines.

SUMMARY

The conclusions made by Piaget and Vygotsky concerning how learning occurs form the basis for a theory (scheme) of an educative process that closely approximates a natural method for learning. Piaget's concept of stages that must be experienced as part of normal development is coupled here with Vygotsky's concept of the zone of proximal development. By merging these ideas a foundation for an ungraded/multiaged organization of child placement in school is constructed. In a collateral addition, Piaget and Vygotsky believe that knowledge is constructed by the individual through tools (objects) This belief confirms the practices developed by Froebel in his kindergarten. In total this is the foundation of a constructionist approach of the theory.

This theory embraces the full life span of the individual and stresses adaptability as a survival strategy in a civilization where change is inevitable, continuous, and unpredictable. The theory leaves in place traditional content, but not the traditional *delivery* of that content (through the pouring metaphor) since it is not to be passively delivered but actively constructed. As one byproduct, it is this constructing process that allows the student to achieve the goals the state wishes through the mandated technology.

Admittedly, the theory goes in the face of a century of faith in linear scientific answers to the question of how learning is accomplished. The traditional model is based on the idea that children of the same age can be effectively grouped; in contrast, this scheme addresses the individual, neutralizing the conflict centered around homogeneity and heterogeneity. Furthermore, the older model is based on the idea that age groups can be treated as statistical herds and moved by formula through grade levels as a unit; in contrast, *this* theory encourages seamless transitions constructed by the individual in a noncompetitive, participatory milieu.

DISCUSSION

Most educators have not fully understood the role of computer related technology in the schools. This lack rises from two sources: the paucity of technical training itself ; and, the want of an elemental vision derived from current understandings of how learning comes about. Like the limited world view of the prisoners in Plato's cave, their thinking is a logical outgrowth of blind reliance on traditional practice and behaviorist methodology. This world view is the only one they know. It is a view that has been reinforced by narrow and often symbiotic research practices that provide support to a pedagogy that is not relevant to the contemporary milieu in which rapid change is the dominant feature. It is one in which conflicting political mandates are imposed without an understanding of the consequences. It is a world view that is based on cognitive illusions.

To understand the role of technology in the school the educator must leave that shadow world of the cave. The result will force a restructuring of curriculum such that the acknowledged role of technology within the larger society will be merged with the students' experiences with the same technology in the school. From this merger will evolve a vision and a curriculum structure that will be closer to the needs of the larger society.

In this paper I have broken with the tradition of exploring educational issues from within the institution. This tradition would focus on one narrow topic, such as *the effect of interactive video on students in a freshman biology class in a trimester school program.* Numberless papers have been written from this type of narrow focus, complete with the statistical justifications that are the delight of those who equate mathematical facts with scientific reality. It is this very narrowness of the traditional approach that interferes with an understanding of the effects of technology and the broad implications of a mandate such as *Ohio SchoolNet.* Recent technology is not an isolated event in the same sense that radio was an event that might possibly be studied in isolation. Any attempt to quantify—to measure—an event is a cognitive illusion. It is like the construction and proof of a Möbius strip.

The Möbius strip is a topological construct that is formed physically from a rectangular strip of paper. The two narrow ends are joined after a 180° twist. The resulting shape appears to be three dimensional but really has only one dimension. This can be proven empirically by drawing a line down the center without raising the pen or pencil from the surface. The proof occurs when the line meets the point of origin. This shape is described by a perfectly valid and scientific mathematical formula.[36]

While my perspective is, and can only be, from the position of the teacher within the institution—more narrowly, from within the classroom—I have chosen to explore the belief that humans individually *construct* their learning and view of the world using a method that is found in the concepts of *constructionism.* The technique that I use is suggested in the purposes of the science of complexity which seeks to understand the ambiguous areas between the sciences. In this case, the between that exists in the relationships of student, teacher, and curriculum and instruction. I define this area as one of four facets of a totality called Education and assign the label *Classroom* to it. Classroom is more than a cell in a building; it is an area that is ephemeral and tenuous. It is a between.

The conflict that originates from the mandated mapping of technology onto curriculum is derived from two incompatible illusions. One is political; the other institutional. The political illusion rises from the politician's ignorance of the purpose of schools. It is derived from the vision that a populist panacea can correct the ills of education caused by lengthy neglect through a massive infusion of money. It is a blatant and cynical appeal to the *acquisitive organ* of the school.

The school illusion rises from its ignorance of the nature of the state of change engendered by technology. It envisions an absorptive process in which it is possible to forge the technology in some such way that it will fit into the pattern of rote learning that is driven by state mandated testing under the guise of accountability. It is a vision that sees the ends of education as an agent in a sorting process for the state.

These disparate illusions cannot be reconciled. As a creature of the state, the school has no choice but to follow the dictates of the state. The mandate has been broadcast, and the money and accompanying wires are flowing through the acquisitive organ. The hidden consequence, reform, *will happen*. The question is one of form: the shape that the reform will take. Will the rioting hungry destroy the bakeries in their ignorance? Will the reshapers destroy the schools in *their* ignorance?

The purpose of this paper is to contribute to the process that is needed to reconcile the reform consequence of the mandate. To do this, I explore an alternative vision of the between of curriculum and instruction and provide a skeletal form that is built on constructionism. I have adopted the attitude that contributing concepts of how humans learn can be culled, not just from the literature under the rubric of education, but from a variety of disciplines, especially from the cognitive sciences. This exploration is also oriented in time in that it draws from the past and the present, recognizing that the future is the driving force through change. I draw from the past forgotten (Froebel), the past under-appreciated (Piaget), and the past rediscovered (Vygotsky). Current thought in the cognitive sciences is evolving, but, I believe that it supports the theory of self-constructed learning.

The lens of present practice defines the current role of technology in the school. It is formulated by most teachers, their students, and the public. This definition, like the Möbius strip, is a scientific construct not found in nature. It is a construct that is based upon a cognitive leap into the illusion that all things are measurable. Removing this 180° twist restores the visual gap between reality and illusion, allowing the teacher and student relationship to metamorphose from an adversarial state based on a loss of trust into one of collegiality in which the student and teacher trust each other to co-build learning.

The introduction of technology with its glut of information generated daily will lead to a dismantling of the fragmented, over-specialized content areas that is understood to be the curriculum. The resulting replacement will be a curriculum in which knowledge is viewed in terms of a continuing construction rather than in terms of some fixed end of itself. Any response to an increasingly ubiquitous technology infers a shift in an understanding of the *raison d'état* and *raison d'être* of Education.

The lack of understanding mirrors the larger inability of the institution to quickly and effectively respond to rapid global, national, and regional economic, political, and cultural changes. Again, one reason for this can be found in a historic perception that curriculum change must be driven by subject content. Under the influence of this point of view, teachers, administrators, and curricularists try to force a questionable match. In the process the real power of technology to effect change is in danger of being diluted and the vision of democratic education eroded, magnifying class differences.

This paper is oriented toward one facet of Education that I have labeled Classroom. In the paper there are three other facets that are not addressed and need exploration:

1. *Feedback*. If testing as understood today is flawed, as is argued here, then what replaces it? Have the advocates of *authentic assessment* really thought of evaluation in terms of projects that are outside the realm of simulated experiences? The citation from the ACOT study only hints at the problem.
2. *Training*. Most of the modeling that teachers receive is derived from their experiences during their education. The modeling in teacher training institutions seems to follow the same model (I have experienced three:

Bridgewater (MA) Teacher's College, Youngstown State University, and Kent State University).

3. *Milieu.* The comprehensive global, national, state, county, local community, and family influences are the primary learning environments of the student. This is the region of the hidden curriculum (e.g., while this paper leaves the politician wallowing in cynical ignorance, his plight is counterproductive to the larger goals of the society).

The event that triggered this search rose from the imposition of technology on the school by edict. That political decree contained a hidden consequence: The schools of Ohio (and America) will reform. The shape of that reform has not been articulated. Articulation with one voice is not possible because the politicians are in one cave and the teachers are in another. Both caves are under separate cognitive illusions. That situation can be an opportunity for a defining assessment of how learning happens. That situation can be an opportunity for creative change without destroying the institution.

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ENDNOTES

[1] In Wise's introduction, he reviews seven previous studies (Eastman-Wood-Freeman included) In one, made in 1918, the author finds that the experimental group retains about 20% more after three months than the control group (p. 4).

[2] One other finding worth mentioning concerned reading. Wise found that the experimental group universally averaged more pages of reading material than the control group (p. 113).

[3] I will discuss empirical experiments in education later.

[4] The series of films used was titled *Chronicles of America Photoplays*.

[5] Weinand gives the name of the school as *Harlem* High School. In reporting this experiment, Levenson (1945, p 31) identifies the school as Haaren High School. Using Levenson as his source Cuban (1986, p. 19) also names the school Haaren High School. The contemporary account in the New York Times reports *Haaren* as the name of the school ("Solve Problems", 1923).

[6] I will return to this point since it is central to my thesis. While technology can serve as an adjunct to the curriculum, it bests serves the student when it is used to construct learning.

[7] The evolution of this confluence will be discussed in the section on Classroom practices.

[8] It must be pointed out that until the late 1970's the computer was some form of mainframe or minicomputer. The microcomputer (later called personal computer) did not exist.

[9] My personal interest in computers began while in high school. The popular press was reporting Wiener's work in cybernetics and my drama class was reading Câpek's *R.U.R.*

[10] This is an example of what I call the bake sale economy that plagues schools. It is unfortunate that so much effort is expended on subsidizing the school.

[11] Henry Goddard, the editor of the 1916 American edition of *The Development of Intelligence in Children* (1916/1973), coined the word moron to replace Binet's term *débile*, which would be translated as feeble-minded and cause confusion in British and American circles.

[12] For example, David Berliner and Bruce Biddle (1995) quote the cautions published by the College Entrance Examination Board (SAT): "Using these scores in agregate form as a single measure to rank or rate teachers, educational institutions, districts, or states is invalid because it does not include all students. In being incomplete, this use is inherently unfair."

[13] William Gasser echoes William Demming's *Total Quality* concept when he titles his book *The Quality School* (Glasser, 1992, 1990) But Glasser is advancing an attitude; Demming suggests a method. Words like excellence, quality, thought(ful), and democratic abound in the literature and are sure sells to the faddist.

[14] Lesson plans were not a new phenomena. Some early educators found a need for them. Francis Parker, in his Quincy School, felt that an effective lesson had to be planned, for example (Patridge, 1891). Formal planning elsewhere was voluntary and far from universal. The theory of Taylorism mandated the lesson plan as one more control and deskilling device.

[15] In addition to the good-old-boy connotation of the whole word, the initial phoneme of this word is intended here, through echo, to suggest two phenomena: the advancement of administrators through their relationship with sports; and the dominance of sports metaphors in the literature. The first reflects the hiring practice that places emphasis on coaching ability as opposed to scholarship; the second might come from the first: those coaches who advance in scholarship are more comfortable with sport referents than literary allusions.

[16] This number depends on how literally the teacher understands the quasi-optional classification for some items.

[17] The data are now on CD ROM and can be accessed by other researchers.

[18] In my model for students, I cheat on body: I use heavy overhead transparency film.

[19] Figure 9 is not complete. Its use here is to demonstrate the process. A truly definitive chart would be too unwieldly.

[20] These are similar to Howard Gardner's (1991) Curriculum (Classroom), Community (Milieu), Teacher Training (Training), and Assessment (Feedback). Gardner's narrow focus serves his argument. A broader focus serves mine.

[21] The bias was not universal. One of my several lives was as the middle manager of the international department in the home office of a multi-national manufacturing company. Because manufacturing operations or local modifications had to be performed on cite in company plants anywhere, all drawings were converted in the 60s to show both metric and U.S. standard measurements. At one planning meeting, one engineer questioned why the company was bowing to pressures from "them krouts, frogs and japs." He was gone within six months.

[22] Mortimer J. Adler, Chairman; Jacques Barzun; Otto Bird; Leon Botstein; Ernest L. Boyer; Nicholas L. Caputi; Douglass Cater; Donald Cowan; Alonzo A. Crim; Clifton Fadiman; Dennis Gray; Richard Hunt; Ruth B. Love; James Nelson; James O'Toole; Theodore T. Puck; Adolph W. Schmidt; Adele Simmons; Theodore R. Sizer; Charles Van Doren; Geraldine Van Doren; and, John Van Doren.

[23] In practice many teachers claim to use question-and-answer dialogs in their teaching. Adler would go beyond their understanding of the technique. His method would be more challenging than anything I have observed being practiced. It would be closer to a dialectic rather than merely dialog.

[24] This logic is relativist in nature. In the moral black and white absolutism of fundamentalists, it is already seen as a major threat.

[25] The debate took place in October of 1975 at the *Abbaye de Royaumont* near Paris.

[26] In his 1955 novel, *Auntie Mame*, Patrick Dennis describes being enrolled (c. 1930) in a progressive school where all (male teacher, female assistant, and children of all ages) completed the educative agenda completely nude.

[27] Papert is generally given credit for Logo, but it was ". . . developed in 1968 by W. Feurzeig, S. Papert, M. Bloom, R. Grant, and C. Solomon at Bolt, Beranek and Newman, Inc., in Cambridge, Massachusetts. Their work was sponsored by the National Science Foundation. Further work on Logo has been done at the Massachusetts Institute of Technology in the Artificial Intelligence Laboratory and in the Division for Study and Research in Education. The name 'Logo' is not an acronym; it was coined by Feurzeig and is derived from the Greek word meaning 'word' or 'thought. . . . Logo is based on the earlier language LISP. . . . In fact, Logo is considered by some to be a dialect of LISP (Taylor, 1988, p.308).

[28] The program was on an audio tape and took almost ten minutes to load from a cassette player. The program could missload if busses were revving their motors outside in the parking lot.

[29] Computed: (180 days x 50 minutes)/60

[30] I am using the term *aptitude* rather than the more formal concept of Multiple Intelligences (Gardner, 1991), but the idea is the same whatever the terminology.

[31] The idea of a flexible plan here is not to be confused with the contemporary inflexible IEP practices.

[32] The holodeck is a 3D virtual reality entertainment center in the later Strar Trek series. Of immediate interest in education are the implications and evolution of a hypertext *Literature* or form of narration that is closer to our experience. This is one change that can be anticipated and enhanced in schools through classes in creative writing or composition. Assuming, of course, that teachers are trained.

[33] Traditional, as used here, does not necessarilly mean a backward movement to some kind of universal liberal arts basics or the basics of a bygone era. It does suggest that topics outside the curriculum that have been introduced into the curriculum (from the hidden curriculum) for social reasons be removed (e.g., career planning)

[34] The post-secondary option in Ohio allows qualified secondary students to take courses at the university during the normal school day.

[35] On a recent trip to evaluate technology installations in schools in the Cincinnatti and Columbus areas, one of the principals in the group used the light towers of football stadiums as visual guides to identify high schools.

[36] The Möbius strip does not exist in reality but its one sided property does have practical manufactured application (e.g., the fan belt in a Corvair).